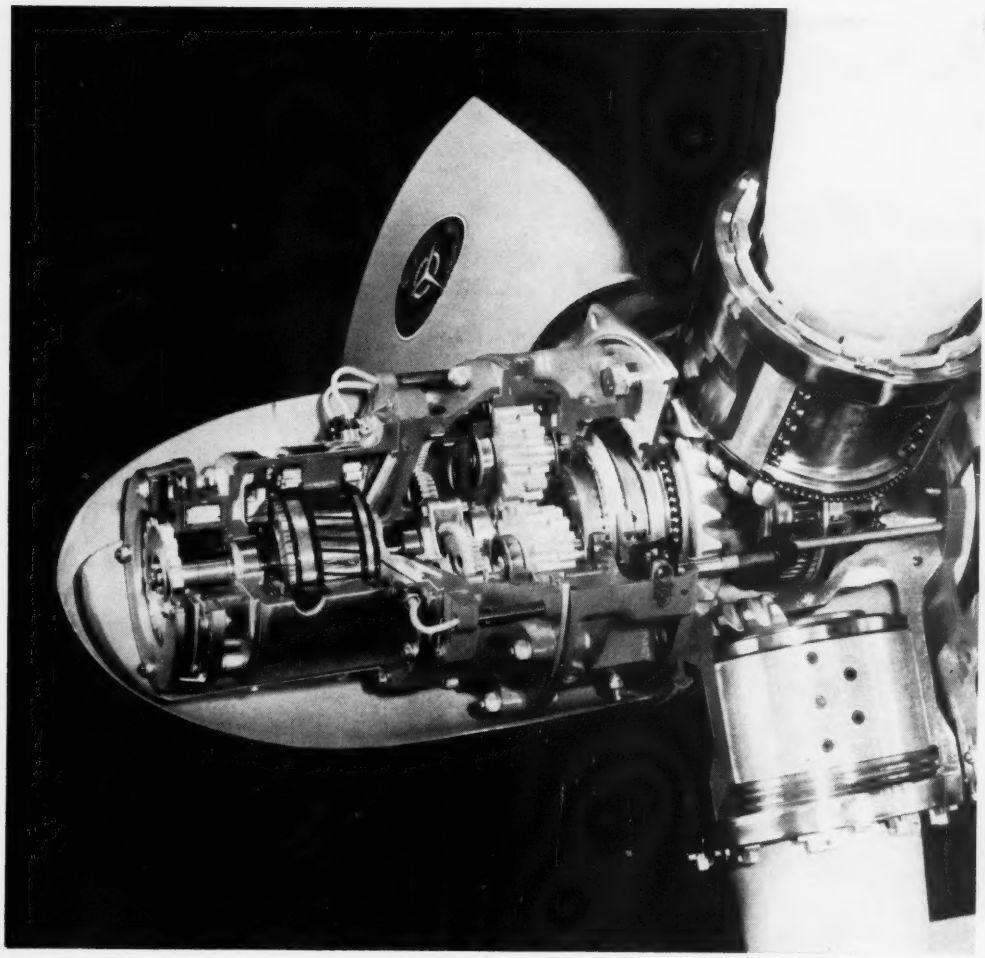
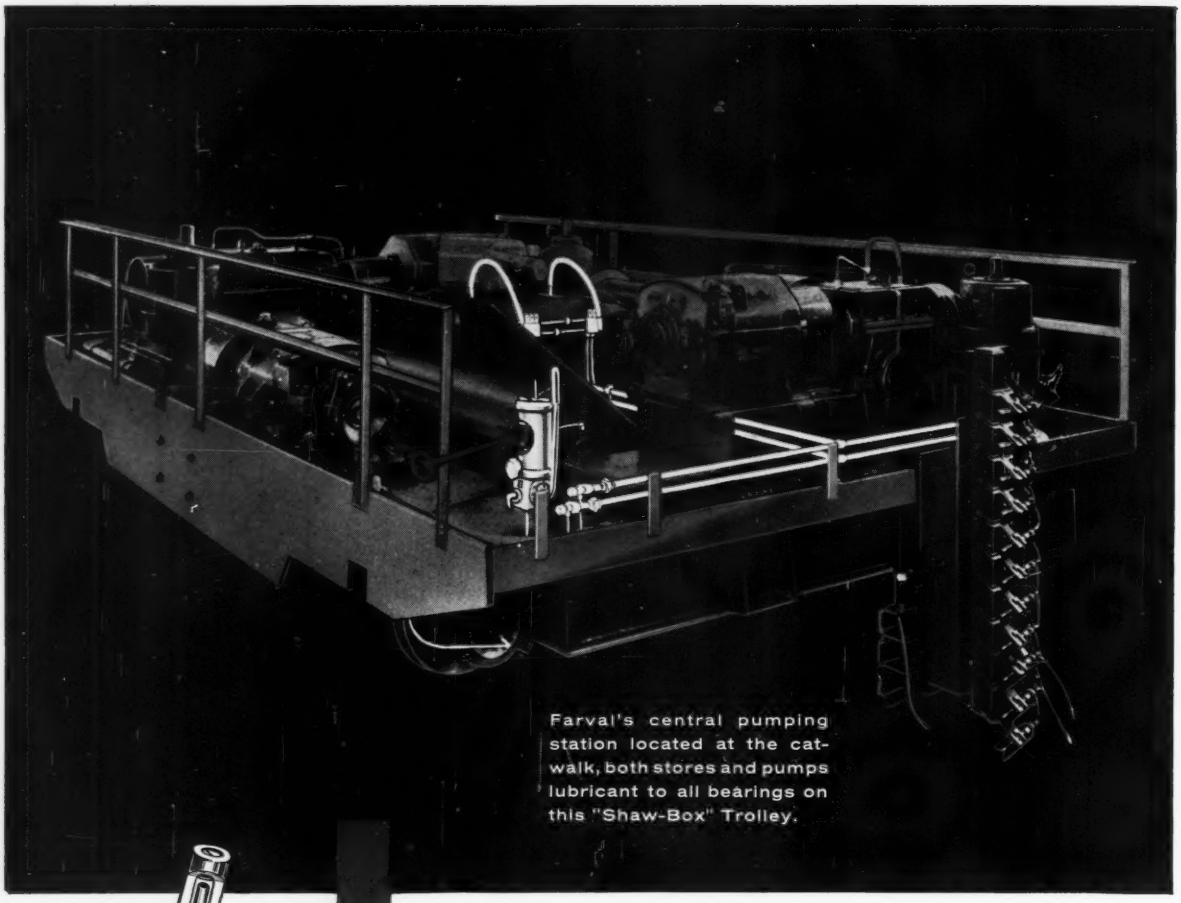
LUBRICATION ENGINEERING

DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE

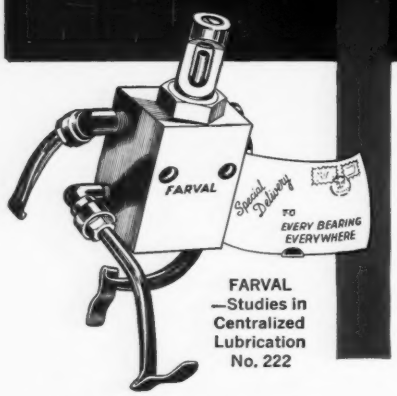


Gear Friction Reduced with Molysulfide (see page 371)

JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS



Farval's central pumping station located at the catwalk, both stores and pumps lubricant to all bearings on this "Shaw-Box" Trolley.



FARVAL
—Studies in Centralized Lubrication
No. 222

Farval helps 200-ton "Shaw-Box" Crane deliver dependable performance

RUGGED "Shaw-Box" cranes, built by Manning, Maxwell & Moore, Inc., moving plates, slabs or giant ladles in steel plants across the nation are noted for safe, dependable service under extreme operating conditions. One big reason for this performance is proper bearing lubrication . . . provided by Farval.

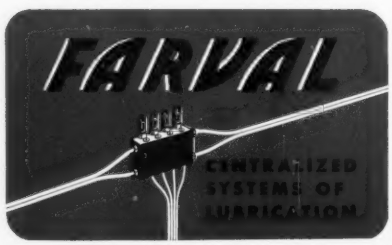
Farval's up-to-the-minute method sends measured amounts of lubricant to all crane bearings from a safe, centrally-located pumping station. Thus the need for men to crawl over the crane with hand grease guns is eliminated.

To see how Farval can help you cut operating costs, ask for revised Bulletin 26-S. Write today to The Farval Corporation, 3267 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

KEYS TO ADEQUATE LUBRICATION

—wherever you see the sign of Farval—familiar valve manifolds, dual lubricant lines and central pumping station—you know a machine is being properly lubricated.



Volume 14, No. 9
September, 1958

Lubrication Engineering

DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE

Contents

LUBRICATION IN PRACTICE

Economics of Oil Reclamation for Railroad Equipment ..... T. W. Potter 382

DESIGN, RESEARCH, DEVELOPMENT

Emulsion Type Fire Resistant Hydraulic Fluids ..... C. E. Francis and R. T. Holmes 385

Techniques for Surface Examination ..... F. T. Barwell 391

CURRENT NEWS

Lubrication in the News 362, 364

Personals 366

Coming Events 371

Industry Notes 366

Cover Story 371

FEATURES

Editorial 381

Lube Lines 379

National Officers and Directors 374

LITERATURE SUMMARIZED

ASLE Technical Digest .. 398

Patent Abstracts 401

Book Review 399

TRADE INFORMATION

Advertisers' Index 404

New Products 377

Product Literature 400

Cover photo courtesy Climax Molybdenum Co.

Abstracted by Engineering Index and Industrial Arts Index

LUBRICATION ENGINEERING is published monthly by the American Society of Lubrication Engineers, 84 E. Randolph St., Chicago 1, Illinois. Current volume single copies 75c. Copies of issues from previous volumes $1.00, if available; copies to foreign addresses add 50c per copy. Annual subscription $6.00 in the USA and Canada, $7.00 to all other countries. Copyright 1958 by the American Society of Lubrication Engineers. ASLE will not be responsible for statements or opinions presented at its meetings or printed in its publications. Second class mail privileges authorized at Chicago, Ill.

John Boyd, Editor
Vera Blake, Production Editor
A. F. Brewer, Consulting Editor
C. L. Willey, Business Manager

ASLE Publications Committee

D. W. Sawyer, ALCOA Research Laboratories, Chairman
John Boyd, Westinghouse Research Laboratories
J. Willard Peterson
Standard Oil Co. (Indiana)
C. A. Tomczak
C. L. Willey

Editorial Review Committee

John Boyd, Chairman
W. E. Campbell, Afram Consultants
R. K. Gould, Beacon Laboratories, Texas Co.
A. A. Raimondi, Westinghouse Research Laboratories
E. E. Bisson, NACA
John Givens, Shell Oil Co.
Ernest Rabinowicz, MIT
M. C. Shaw, MIT
L. B. Sargent, Jr., ALCOA Research Labs.
H. W. McCulloch, Jr., Shell Oil Co.
L. E. Hoyer, American Brake Shoe Co.

Publishers Representatives

Eastern Region

ASLE
84 E. Randolph Street
Chicago 1, Illinois
DEarborn 2-1298

Central Region

DWIGHT EARLY & SONS
100 N. LaSalle St.
Chicago 2, Ill.
CEntral 6-2184

Western Region (15 States)

McDONALD-THOMPSON
San Francisco 5, Calif.
625 Market Street
YUkon 6-0647
Los Angeles 5, Calif.
3727 W. Sixth Street
DUnkirk 7-5391
Seattle 4, Washington
1008 Western Avenue
ELliot 3766
Denver 2, Colorado
Colorado Nat'l Bank Bldg.
KEystone 4-4669
Houston 6, Texas
3217 Montrose Blvd.
JA 9-6711
Tulsa 4, Oklahoma
2010 South Utica
RIverside 3-1981

Soviet Economic Threat Faces U.S. Aluminum Industry

Indignant at the threat of economic competition from Russia, Reynolds Aluminum Co. printed a no-holds-barred article on "The Threat of Red Aluminum" in their July-August issue of *Reynolds Review*.

Introducing the problem of United States competition against the "dumping" of rock-bottom priced aluminum on world markets, Reynolds' President R. S. Reynolds, Jr. stated that U. S. aluminum companies are at a severe disadvantage when competing with foreign, government-subsidized aluminum companies whose labor costs are much lower than those in our country President Reynolds emphasized that U. S. aluminum companies cannot defend themselves against Russia's action without "more realistic government policies and procedures" without which "we cannot compete successfully against other foreign aluminum companies.

According to the *Review*, the Russian bloc imported large amounts of aluminum from the free world until about three years ago. Suddenly, in 1955, Russian aluminum began to appear in the international market in large amounts Last year, the Soviet fed 37,000 tons of aluminum into the trading arteries of the free world.

The reason for this lies in the Sputniks. With the advent of the missile age, military requirements—for aircraft primarily—dropped appreciably. Guided missiles and supersonic airplanes don't consume the tremendous amounts of light metal that the pre-missile air power required. In America, where more than 90 per cent of aluminum production goes to civilian consumption, the change in military requirements did not have the impact that it had in Russia. There, with virtually all aluminum going to military use, the change in requirements created a great surplus of aluminum.

Significantly, the Russians did not to our knowledge cut back production to adjust to the new situation. They continued producing and expanding. Aluminum, until 1955 used to make their weapons, had now become a weapon.

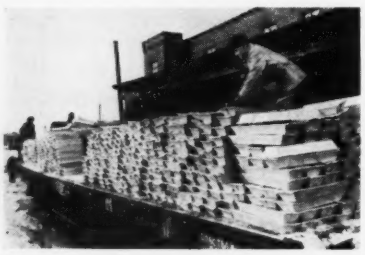
In the past three years, more than 80,000 tons of Russian aluminum has hit the world market. Reynolds reports that there is a pattern: it appears in large quantities sporadically and is priced to undersell all existing suppliers.

Since the aluminum industry in Russia is nothing but an arm of government, the price for which it sells bears no relation to the cost of producing it. Slave labor or low-wage workers, state-owned bauxite mines, state-owned transportation, state-owned plants and equipment . . . no interest, no taxes, no accounting. No one knows exactly how much it costs the Russians to produce a pound of aluminum. Whatever it costs them, the Russians are unfailingly selling at whatever price will beat the free world producers.

To date, the Russians have sold mainly in Europe, also in India and Argentina. But the fortunes of the American aluminum market are tied to the conditions of the world market. The impact of Soviet aluminum in these areas has been felt here.

One of the most significant Russian moves in their campaign of economic warfare occurred in early June when Premier Nikita Kruschev wrote an eight-page letter to President Eisenhower listing many items which Russia would like to buy and offering a similar list of things it was willing to sell to America in exchange.

A single item on the Soviet's "wanted" list is a key to Russian designs: equipment for rolling non-ferrous metal. Aluminum is non-ferrous metal. Russia, it would seem, wants to compete not only with its aluminum pig, but with rolled and fabricated aluminum.



Loading aluminum pigs on a railway flatcar at a Russian aluminum works in the Kemerovo region of Siberia.

(Photo by Sovfoto)

Execs' Salaries Rose 4.8% in 1957

The salary of the "average" business executive in the middle management category increased 4.8 per cent—from $11,240 a year to $11,800 a year—from last year to this year, The American Management Association's seventh annual survey of middle management compensation indicates.

The sixth annual middle management survey, issued a year ago, reported a 5.8 percent salary increase for a corresponding period of time. The lower salary increases granted during the past year, the current report notes, apparently reflect the leveling off in business activity that developed in the latter part of 1957.

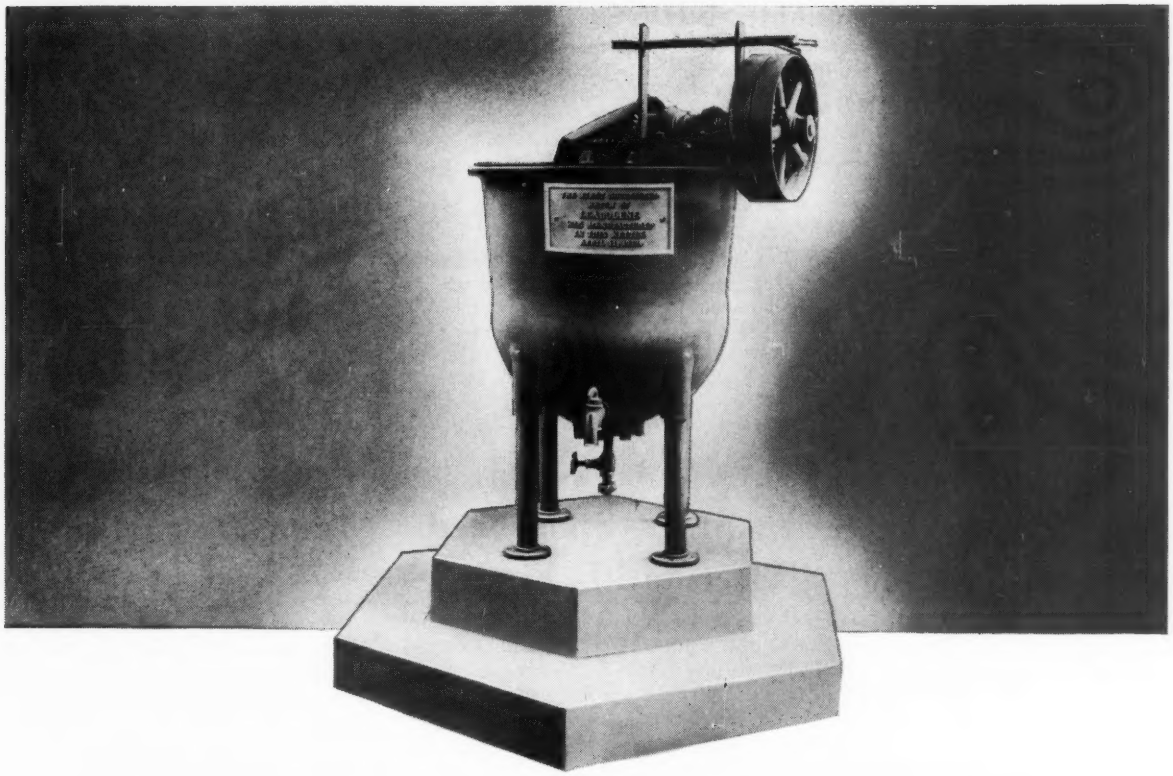
The new study covers the compensation paid to more than 8,100 executives in 286 companies throughout the United States and Canada. These executives hold such titles as plant manager, regional sales manager, chief accountant, labor relations manager, general attorney, and product development engineer in the fields of marketing, production, finance, law, purchasing, industrial relations, engineering, and research. Included are 46 types of positions in the category of middle management, between the top policy-making level and that of lower supervisory management.

In small American companies middle management salaries usually range from about $6,000 to about $15,000 a year, while in large companies they may go as high as $30,000, the AMA report shows. Factors other than company size have a decided effect on salary levels. For instance, the pay of a plant manager is related to the production volume of his plant, and that of a district sales manager correlates with the volume of sales in his district. Geographical location within the United States does not seem to be a significant factor.

Widest Stretcher Now in Operation

The widest stretcher for aluminum plate in existence has been installed and put into operation at Aluminum Company of America's Davenport, Iowa, plant. The Giant machine—designed and built by Loewy-Hydropress Division, New York City, of Baldwin-Lima-Hamilton Corporation, is over 160 feet long and weighs more than 5,500,000 lb.

It can grip in its massive jaws rolled aluminum plate up to six inches thick and 152 inches wide and can stretch and straighten it at a speed of 24 inches per minute, with a pull of 16 million pounds —enough force to lift a Navy cruiser out of the water. The huge lengths of heavy plate are then cut and milled to make various structural components, such as integrally stiffened skin sections for the largest airplanes.



the FIRST successful batch of LEADOLENE was manufactured in this kettle APRIL 11, 1932

TODAY, our modern facilities, capable of compounding thousands of gallons per day are ready to serve you!

For over a quarter of a century LEADOLENE has been successfully used by leading industrial companies requiring a superior lubricant for the highly specialized industrial field.

In serving industry for 82 years, BROOKS has established an outstanding reputation for producing lubricants of the highest quality.

The BROOKS OIL COMPANY produces a variety of SPECIAL industrial lubricants—LEADOLENE—KLINGFAST — BARCOTE — ROLLENE. Heat resisting lubricants of both plastic and fluid types; forging and drawing compounds; and other special plastics and fluids which have set new standards for performance and economy. Talk it over with the BROOKS OIL man near you.

THE BROOKS OIL CO. 1876 1938 62nd YEAR

A new 16 page brochure available on request.

The Brooks Oil International Company: Exporters

OFFICES AND WAREHOUSES IN PRINCIPAL CITIES U. S. A. • CANADA

The BROOKS OIL Company

Established 1876

General offices and U.S. plant: 3304 East 87th Street • Cleveland 27, Ohio
Canadian offices and plant: 461 Cumberland Avenue • Hamilton, Ontario

Joint Lube Confab Reflects Atomic — Space Age

Lubrication under the extreme conditions created by atomic power projects and ventures into space will highlight the discussion at the fifth annual joint ASME-ASLE Lubrication Conference at the Statler Hotel, Los Angeles, Calif., October 13, 14 and 15.

Two papers will deal with the effects of high energy radiation on oil and the development of oils to resist these effects. Problems of lubrication and seals that result from extremely low and extremely high temperatures will be covered by papers dealing with gas lubricated bearings, bearings and seals operating in liquified gases, and investigation of dry adhesive wear, materials for rolling contact bearings for temperatures of 450°F, and metal friction and wear and rolling contact fatigue at elevated temperatures.

In addition, other papers will deal with the visco-elastic properties of grease, the effect of offset loads on the performance of partial journal bearings, the elastic and damping properties of journal bearings, characteristics of the three-lobe bearings, oscillating plain bearings, the mechanism of gear lubrication, adhesion between metals and transition temperatures in sliding systems, the conduction of current in bearings, surface effects of oils containing zinc dithiophosphate, film formation by an anti-wear additive, and some factors affecting rolling contact fatigue.

A program for the ladies, sponsored by the ASME Womens' Auxiliary includes an all day tour to Disneyland, Knotts' Berry Farm, Knotts' Ghost Town and Arabian Horse Farm. A second tour will include visits to the Los Angeles Coliseum, Hollywood Park, Exposition Park, Marineland, Palos Verdes Estates plus a drive along the Pacific Ocean.

AMA Backs Up ASLE — Sponsored Dermatitis Findings

Backing up the findings of the April 1956 ASLE-sponsored Industrial Dermatitis Symposium, a committee of the American Medical Association has found inflammation of the skin, the most common industrial disease, to be largely preventable.

Lack of personal cleanliness is the most important factor in the development of occupational skin disease, the committee said in a report in the August 30 A.M.A. Journal.

Most cases of acute occupational dermatitis occur in young and new workers who possibly are less careful and who often fail to observe suggested hygienic practices.

Contact with chemicals accounts for 90% of all industrial skin diseases, the report said. Petroleum products and greases, alkalies—including cement, and solvents lead the list of causative agents.

Physical agents, such as exposure to sun or heat, mechanical injuries, and biological agents such as bacteria and plant poisons also cause dermatitis.

U.S. Bearing Proposal Accepted by I.S.O.

Most of the proposals made by the American delegates for this year's ISO Technical Committee Meeting 4—Ball and Roller Bearings—were accepted, thanks to the preliminary work done by the Annular Bearing Engineering Committee, the Roller Bearing Engineering Committee of the Anti-Friction Bearing Manufacturing Association, and ASA Sectional Committee B3. About 80 delegates from 18 countries met in Naples in June to discuss standards for airframe bearings, instrument bearings, tapered roller bearings, identification codes, tolerances, and load ratings. Major agreements were reached in several of these areas.

GUIDE TO AVAILABLE PUBLICATIONS

INDUSTRIAL DERMATOSES—PROTECTION PREVENTION AND TREATMENT
Medical practitioners, chemists and lubrication engineers examine use and handling of cutting oils, lubricants, and solvents and discuss protective measures in terms of ointments, housekeeping, and prevention of bacterial decomposition.

INTERPRETING SERVICE DAMAGE IN ROLLING TYPE BEARINGS
Manual on ball and roller bearing damage includes drawings, tables and photos to aid in classifying and identifying causes of bearing damage. $1.00. Foreign $2.00

LUBRICATION ENGINEERING DECENNIAL INDEX
Subject and Author Indexes list papers published in *Lubrication Engineering*, Volumes 1 through 10 (1945 through 1954). $.50. Foreign $1.00

PETROLEUM-TYPE HYDRAULIC FLUIDS
Second in monograph series covers Hydraulic Oil Specifications and Service Properties, Viscosity, Viscosity Index, Demulsibility, Oxidation Stability, Lubricating Value, Rust and Corrosion Preventive Qualities. $1.00. Foreign $2.00

PHYSICAL PROPERTIES OF LUBRICANTS
First in ASLE monograph series covers Viscosity, Density and Specific Gravity, Cloud and Pour Points, Flash and Fire Points, Carbon Residue, Neutralization Number and Interfacial Tension, Saponification Number, Emulsification, Specific Heat. $1.00. Foreign $2.00

ASLE
84 E. RANDOLPH
CHICAGO 1, ILL.
Please send me

- ☐ Industrial Dermotoses _____ copies
- ☐ Interpreting Service Damage _____ copies
- ☐ Decennial Index _____ copies
- ☐ Physical Properties of Lubricants _____ copies
- ☐ Petroleum-Type Hydraulic Fluids _____ copies

Enclosed please find $_____ (check) (money order)

My name _____

Address _____

City _____ Zone _____ State _____

One of the 3 essentials for grease manufacturers is EXCELLENCE . . .

Number 4 of a series

BARAGEL* provides EXCELLENCE

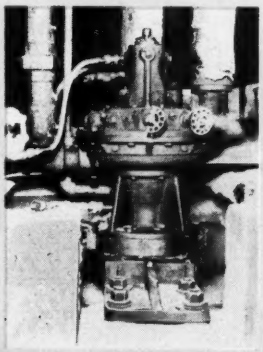
BARAGEL provides EXCELLENCE because of . . .

1. LONG LIFE . . . greases compounded with BARAGEL . . . last longer . . . require less frequent application.
2. WATER RESISTANCE . . . greases compounded with BARAGEL . . . do not wash out when submerged in water.
3. HEAT STABILITY . . . greases compounded with BARAGEL . . . do not melt even when exposed to extreme heat.

LONG LIFE

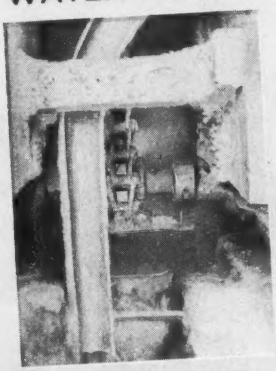
Here are conveyor troughing idlers on a feed belt assembly. By using BARAGEL grease . . . less lubricant is required . . . lubrication was reduced from daily basis to once every 3 months.

HEAT STABILITY



A high temperature application of BARAGEL grease used on all bearings in steam drive turbines. Lubrication was reduced from daily to weekly basis. BARAGEL grease did not run at 320°F turbine temperature . . . at speeds of 4,000 to 5,000 rpm.

WATER RESISTANCE



Bearings on the shaft of this drag box are completely submerged in water at all times. Use of BARAGEL grease, under such conditions, proved far superior to any other type previously used.

BAROID

BAROID CHEMICALS, INC.

A SUBSIDIARY OF NATIONAL LEAD COMPANY

1809 SOUTH COAST LIFE BLDG. HOUSTON 2, TEXAS

*Trademark of National Lead Co.

PERSONALS

Harry W. Kole has been appointed district sales manager by Kelite Corporation, manufacturer of industrial chemicals and steam cleaning equipment.

Judson T. Moore has been named regional sales manager of the Stephens-Adamson's Standard Products Division, Cleveland.

Trimount Instrument Company has announced the appointment of Roger Hezarifend as chief engineer, formerly in the aircraft research division of a Chicago hermitic switch manufacturer.

American Potash & Chemical Corporation has named Roy B. McCrady as distributor for the company's refrigerant products in Missouri and southern Illinois.

Dr. Bernard M. Sturgis, director of the du Pont Company's Petroleum Laboratory, has been named secretary of the Division of Petroleum Chemistry of the American Chemical Society. He succeeds W. G. Lovell of the Ethyl Corporation, who has held the post for several years.

Establishment of a nuclear energy and power plant section of the sales development department and appointment of Frank S. Briggs as manager were announced today by Tube Turns, of Louisville, Ky., a division of Chemetron Corporation.

H. A. Lord, former superintendent of Texaco's Lockport, Ill. Works, has been appointed general manager of the company's engineering department, effective July 1.

Richard A. Pim has been named chief engineer of the eastern division of L. O. F. Glass Fibers Company.

INDUSTRY NOTES

Flexonics Corporation, general office at Maywood, Ill., has announced the formation of four regional sales offices as an important phase of its new organization plan which is being effected during 1958. The new offices are headed up by regional sales managers, L. J. Cullen, Midwest, at Maywood, R. G. Arnold, Central, at Inkster, Mich., H. V. Tastrom, Eastern, at Elizabeth, N. J., and G. W. Derum, Western, at Santa Ana, Calif. A fifth Regional Office at Memphis, Tenn., is scheduled for future activation.

Operation of a high energy fuel pilot plant for the Air Force began recently at AFN, Inc., located at the Henderson, Nev., plant of American Potash & Chemical Corporation. Quantities of the new boron-based fuel were not disclosed by AP&CC but a company spokesman indicated they are small because the facility is a development unit, not a full scale production plant. All additional information about the plant and the fuel is classified.

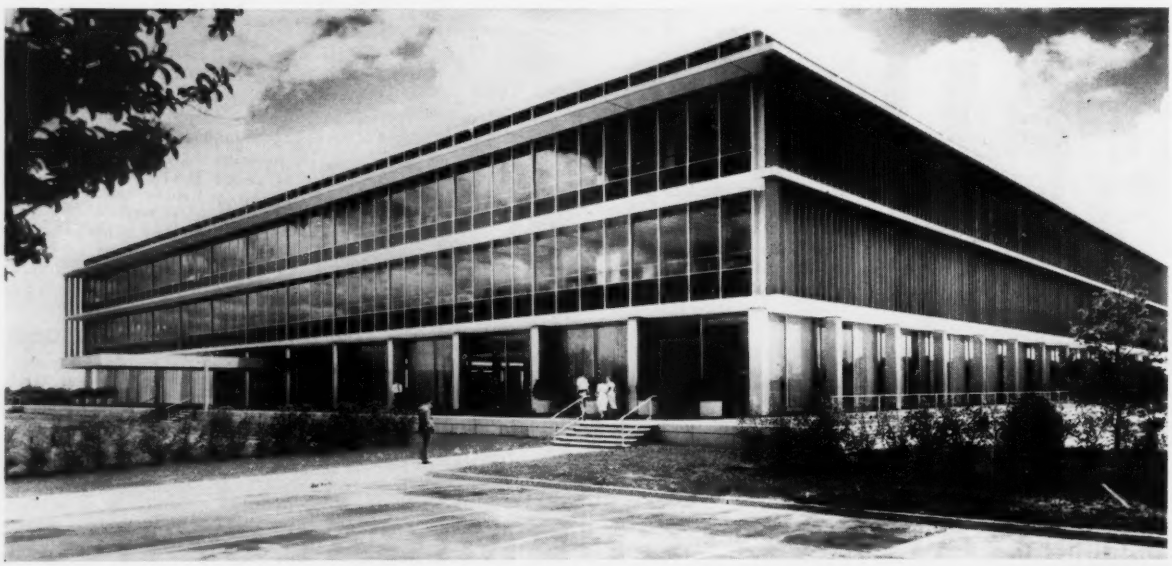
Dravo Corporation, Pittsburgh, has been awarded a contract by the American Steel and Wire Division of United States Steel Corporation for two Dravo-DeLaval custom-designed coolant systems for a 32-inch, 4-high reversing mill at the company's Cuyahoga Works, Cleveland. One of the systems will supply mineral oil coolant at a flow of 450 gallons per minute under a pressure of 100 pounds psi. The second system will supply soluble oil and water at the same flow rate and pressure. Flow pumps, filters and return pumps of both systems will be automatically operated from a main control panel.

Greer Hydraulics, Inc., Jamaica, New York, manufacturers of hydro-pneumatic accumulators, valves and other hydraulic components, as well as ground support equipment for missiles and aircraft, has announced the opening of a new sales office in Dallas, Texas.

American Potash & Chemical Corporation has formed a glass technology section under the direction of Victor C. Swicker.

A new sales district to serve parts of New England, Eastern New York State and the metropolitan New York and New Jersey areas has been established by Bestwell Certain-teed Sales Corporation. The New York sales district is headquartered at 119-121 Summit Ave., Summit, N. J. The district consists of areas of the company's Buffalo and Philadelphia sales territories. The new district is designed to provide these areas with a more closely integrated sales service operation.

A new multi-million dollar office building is the new Richmond, Va. home of Reynolds Metals Company. Designed by Skidmore, Owings and Merrill of New York, the building contains 1,235,000 pounds of aluminum. Aluminum uses include the world's largest system of automatic sun louvers, movable office partitions, acoustical and light-diffusing ceilings, a new line of aluminum office furniture, aluminum yarn draperies and carpeting, and most of the hardware.



The new Reynolds Metals Company General Office Building, Richmond, Va., which contains 1,235,000 pounds of aluminum, is a showcase of the light metal's many uses in modern architecture. Glass walls are shielded by the world's largest system of automatic sun louvers, made of aluminum. The building cost $11.5 million, excluding land and land improvements. It serves as company's new consolidated headquarters for sales, manufacturing and corporate groups.

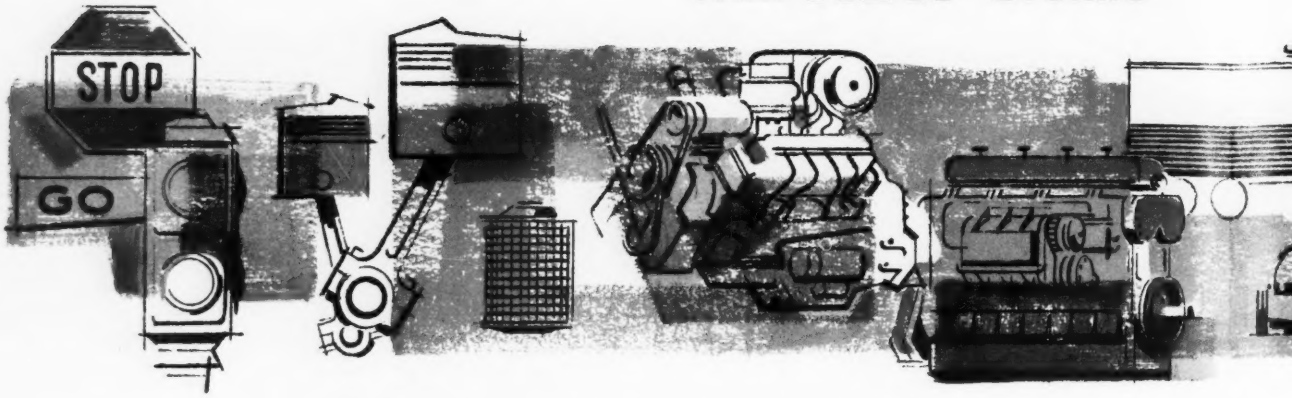
Look what's *NEW* from

ORONITE®

the fastest-growing, major supplier of

LUBE OIL ADDITIVES

With NEW Oronite®



NEW product-performance

Oronite Chemical Company's rapid growth as a major additive supplier is due to continuous and intensive research to provide new and better additive products that are needed today to fulfill the increased demands placed on motor oils by today's more powerful gasoline engines.

NEW CONCEPT—Oronite® "60" Series Additives!

The modern high-compression gasoline engine is very sensitive to wear and deposits, particularly when operating at low temperatures and also because of poorer combustion from "stop-and-start" driving. Today's conventionally compounded motor oils do not control deposits and wear in the later-model engines. These new factors clearly indicated the necessity for a new type oil additive which would reduce deposits under light load conditions without adding to knock or pre-ignition combustion chamber deposits.

New Oronite "60" Series lube oil additives were specifically designed to meet the precise requirements of the modern automobile engine and everyday "stop-and-go" driving service. Behind the development of "60" Series additives was a multi-million dollar research program involving years of laboratory work and six million miles of field testing.

Compounding with Oronite "60" Series additives you will have "years ahead" motor oils that out-date, out perform anything now on the market. You can provide your customers or use in your own gasoline driven equipment, motor oils that are truly designed for the equipment—oils that will provide better engine protection, reduce engine wear, minimize engine deposits and ring clogging, offer better protection against corrosive wear, and oil screen clogging. Longer engine life is assured.

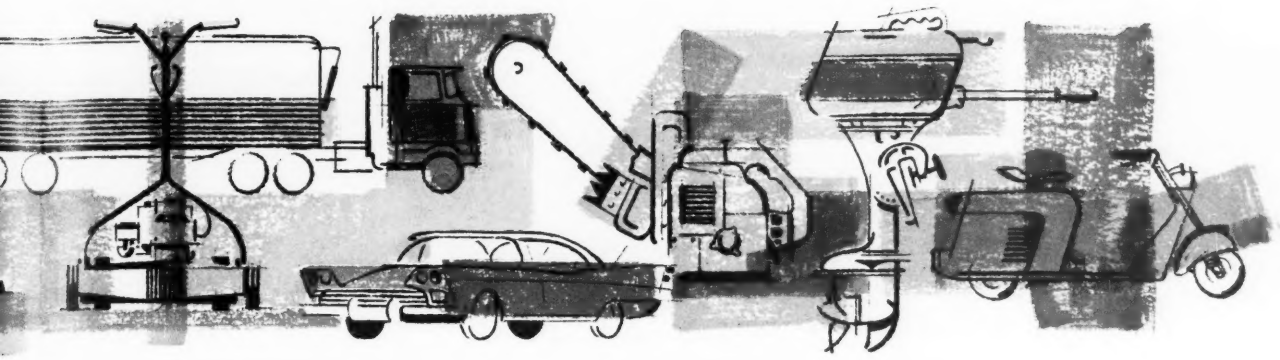
New Oronite "60" Series additives incorporate an ashless detergent component that virtually eliminates oil ring clogging, reduces cylinder and ring wear to a very minimum. The result is a marked improvement in engine life and service under all types of operating conditions.

Oronite "60" Series additives can provide you an important "first" in marketing a superior compounded motor oil for the present and future—in compounding single, dual or multi-graded oils of outstanding performance.

Get the complete story on new "60" Series lube oil additives. Contact the Oronite office nearest you or write for technical bulletin giving complete proof of "60" Series' capabilities.

Copyright © 1958 by Oronite Chemical Company. All rights reserved under Pan-American copyright convention. Litho in U.S.A.

Lube Oil Additives



standards are now possible!

NEW! Two-cycle Engine Oil Additive!

For the first time two-cycle engine oils can be compounded that will solve the lubrication problems normally encountered in two-cycle gasoline engine operation.

Oronite's new additive OLOA 340C was specifically developed for high output two-cycle outboard motors, chain saws, power lawn mowers, foreign motor scooters and bike engines. It offers the oil marketer an opportunity to expand into this rapidly-expanding lucrative market with new advanced oils.

Extensive performance data obtained both in the laboratory and in field testing shows that OLOA 340C additive:

1. Reduces port blocking and keeps power output up.
2. Minimizes ring sticking and piston seizure by controlling deposits.
3. Adds rust inhibition, to avoid engine storage problems.
4. Adds anti-wear properties for protection against EP wear and scuffing.
5. Has anti-plug fouling characteristics.

OLOA 340C is a complete multi-component package additive that can be compounded with any base stock to provide better engine performance and reduce engine maintenance.

Write for full information—field tests, performance ratings, formulations, samples. Contact the Oronite office nearest you.

NEW! Detergent-action Diesel Fuel Additive!

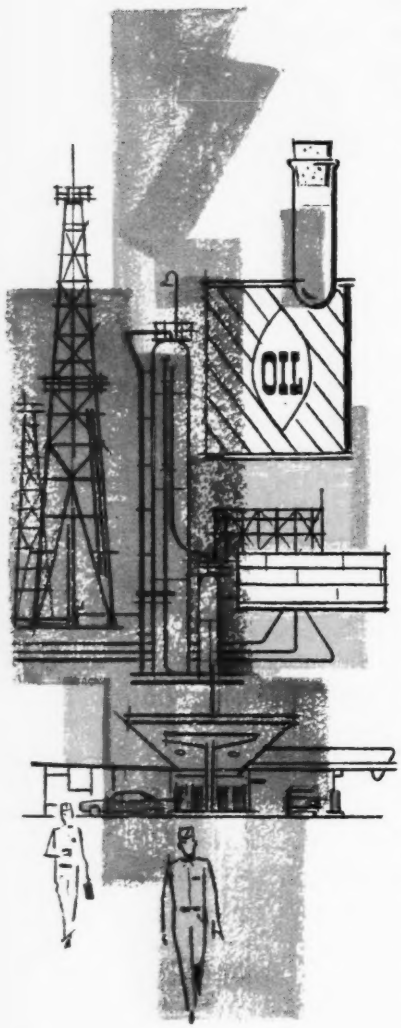
Oronite's new detergent-action Diesel Fuel Additive OFA-265 prevents gums and rust from forming in Diesel Fuel systems. Air pollution is an important problem in most areas today and authorities point to exhaust smoking as contributory to air pollution. By keeping injectors clean for extended periods, diesel fuels compounded with OFA-265 will maintain clean exhausts, high power and low fuel consumption characteristics of new injectors. The improved rust prevention properties of OFA-265 also insures against costly rust damage to fuel systems.

Contact the Oronite office nearest you for complete information on new Diesel Fuel Additive OFA-265.

NEW! A Synthetic Agent for Lubricating Greases!

The unique properties of Oronite® GA-10 gelling agent makes possible the production of superior high-performance grease lubricants for a variety of applications. Whether you make multi-purpose grease lubricants, automotive, aircraft, marine, nuclear reactor or special purpose greases, you will find new Oronite GA-10 offering great new potentials.

Write or phone the Oronite office nearest you for technical bulletin and GA-10 product samples.



Custom formulations to your requirements!

Oronite realizes that every additive application is somewhat different and that each must be considered individually from a price and performance standpoint. Oronite's willingness to provide individual attention to each situation is exemplified by the fact that Oronite supplies over a hundred different additive compounds—having recorded engine tests on many hundreds. Whatever your base stock or requirements from a finished oil—it will pay you to consult with Oronite.

Special-performance or complete-performance additives!

Oil marketers who desire added emphasis on single performance characteristics in finished products specify Oronite's single performance additives. Want added detergent-dispersant or extreme pressure wear properties, greater resistance to corrosive wear or special low temperature performance? Oronite can provide you any of these in single additives. Or, if you require "complete performance" from an additive formulation, Oronite can provide you economical additive "packages," with well-balanced performance characteristics.

Oronite—petroleum and petro-chemical experience!

Working with Oronite, you can draw on the long and valuable experience of people engaged in retail petroleum marketing as well as people who research, develop, manufacture and market additive products. As a leading manufacturer of petro-chemical products, with closely affiliated sister companies in petroleum production, manufacture and research, you can be assured of additive products of dependability, high performance and at fair prices. Why not talk it over with Oronite?

Oronite—research and manufacturing facilities!

From California Research Corporation, Oronite's research affiliate, comes a constant flow of new ideas and concepts to match the challenge of America's engine manufacturers. With "years-ahead" additive products being constantly researched and tested, you can be assured that if you do business with Oronite, you will be FIRST to have the most advanced additive products possible.

ORONITE CHEMICAL COMPANY

A CALIFORNIA CHEMICAL COMPANY SUBSIDIARY

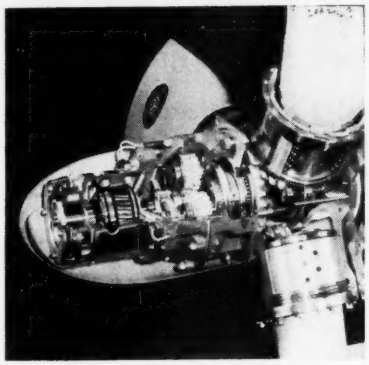
EXECUTIVE OFFICES • 200 Bush Street, San Francisco 20, California

SALES OFFICES • New York, Boston, Wilmington, Chicago, Cincinnati, Cleveland, Houston, Tulsa, Los Angeles, San Francisco, Seattle

Foreign Affiliate: California Chemical International, Inc., San Francisco, Geneva, Panama

4949 31M 7/58

COVER STORY



One of the lubrication demands of modern design—good protection against friction under heavy gear loads—is met by Molysulfide (MoS_2) in this electric propeller produced by Curtiss-Wright Corp., Propeller Division, Caldwell, New Jersey. An additive with unique lubricating properties, MoS_2 is used to reduce friction in the low-speed stage of the double stage planetary speed gear reduction unit (marked by arrow). This gear train controls load and speed of the engine by adjustment of blade angle. Here intermittent mechanical loads create considerable friction. Conventional lubricant films break down under conditions such as this, resulting in galling and scoring of metal surfaces. Molysulfide, with its low friction film, sustains lubrication—hence reduces wear and promotes safety.

To insure adequate protection during break-in, MoS_2 is prefilmed on the gear teeth. A high grade oil containing MoS_2 as an additive is then sealed in the gear unit to provide lubrication during service. Gears are relubricated only during complete over-haul of the propellers. Secret of Molysulfide's success in this high pressure application is a high affinity for metal. It attaches itself to metal surfaces where friction is prevalent.

Curtiss-Wright electric propellers are featured on the new Royal Canadian Air Force Argus, the Air France Super Starliner, and other Constellation series airplanes. (Courtesy Climax Molybdenum Co., Div. of American Metal Climax, Inc.)

COMING EVENTS

October 1-2

Radio Interference Reduction Conference, Museum of Science and Industry, Chicago, Ill.

October 13-15

National Electronics Conference, Hotel Sherman, Chicago, Ill.

October 13-15

ASLE-ASME Lubrication Conference, Hotel Statler, Los Angeles, Calif.

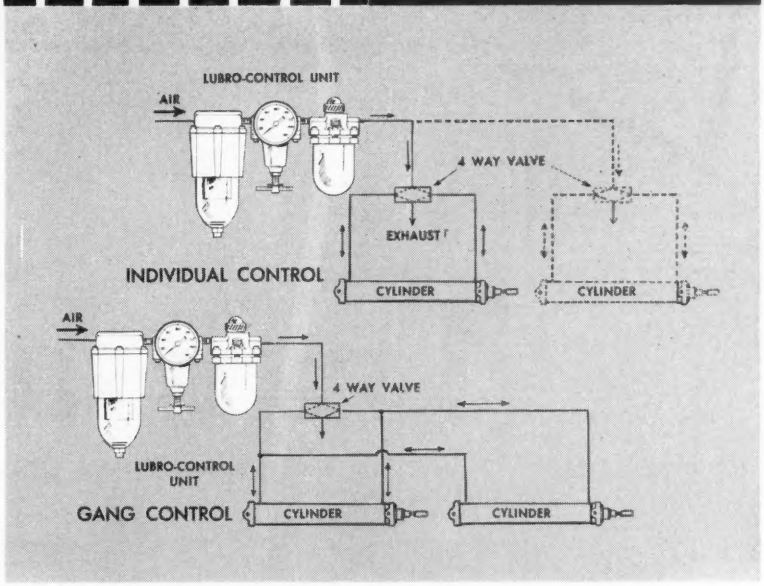
October 27-29

NLGI 26th annual meeting, Edgewater Beach Hotel, Chicago, Ill.

Norgren

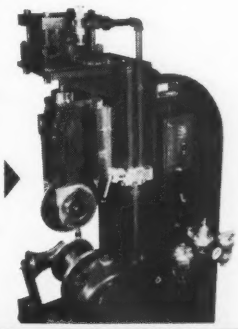
MICRO-FOG LUBRO-CONTROL UNITS

IMPROVE AIR CYLINDER PERFORMANCE



• Increased Cylinder Life
• Lower Maintenance Costs

For top cylinder performance, proper air filtration, regulation and lubrication are vital. The filter removes abrasive solids and corrosive liquids from the air and the regulator provides accurate, unvarying air pressure. Norgren MICRO-FOG, in the stream of air that powers a cylinder, provides ideal lubrication by automatically applying just the right amount of lubricant. Results: better cylinder performance, no scored cylinder walls, no damaged packing, lower maintenance and replacement costs. A single MICRO-FOG Lubro-Control Unit can provide proper compressed air processing for multiple cylinder operation.



Without the compressed air filtration, pressure regulation and lubrication provided by the Norgren unit, it would be impossible to get the close control needed in the operation of this pipe cutting machine.

If it's Norgren...It's Dependable.

For complete information, call your nearby Norgren Representative ... or WRITE FOR DESCRIPTIVE LITERATURE

C. A. NORGREN CO.

3434 SOUTH ELATI STREET • ENGLEWOOD, COLORADO

MEMO TO:

Members Only

Here is the new publication created to provide A S L E members with pertinent information and to increase their fund of scientific knowledge.

SAVE 2/3 THE COST

A S L E
Transactions

231 pages,
27 papers, dealing with ....

- **new bearing materials**
- **high temperature bearing tests**
- **surface fatigue of gear teeth**
- **piston ring wear studies**
- **cutting oil effects on tool life**
- **journal bearing lubrication**

and many more subjects

The most comprehensive publication of its kind! Its sole purpose is to provide a custom publication for the dissemination of information and research data to further the progress of scientific lubrication. It is currently planned to be published biannually.

By ordering now as a member you save two-thirds of the cost to non-members. This is your membership bonus. Be sure you don't miss this opportunity to get the first issue of A S L E *Transactions*—order now!

Available to non-members from
Pergamon Press, Inc., 122 East 55th Street
New York 22, N.Y.

$3.00 per copy
Two issues for $5.00
Use this convenient order form.
MAIL TODAY

A S L E
84 E. Randolph St.
Chicago 1, Illinois

☐ Please send me one copy of A S L E *Transactions* @ $3.00

☐ Please send me two issues this year @ $5.00

Name_____

Address_____

Company_____

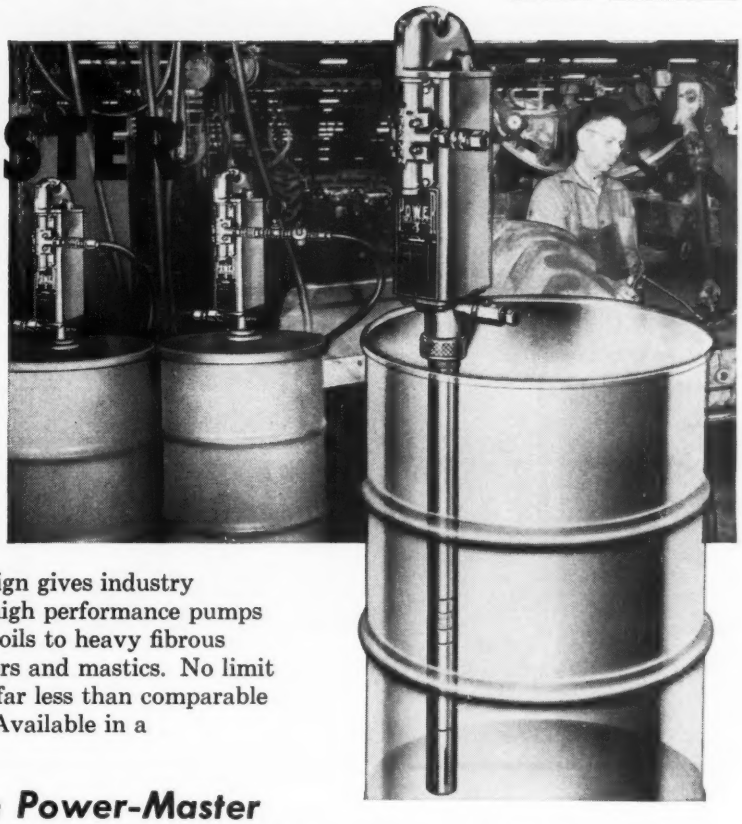
City_____ Zone____ State_____

☐ Bill me ☐ Bill company ☐ Remittance enclosed

Now, from *Lincoln* ... the first really new air operated pumps on the market in 20 years!

THE *New* POWER-MASTER SERIES PUMPS for lubricants and materials assure

- Unmatched Versatility
- Top Performance
- Long Service Life
- Maximum Economy



Power-Master ... years-ahead design gives industry a complete range of dependable, high performance pumps to handle all materials from light oils to heavy fibrous greases and viscous coatings, sealers and mastics. No limit to industrial applications ... cost far less than comparable pumps to operate and maintain. Available in a great number of pressure ratios.

It pays to standardize on Power-Master

HIGH VOLUME OUTPUT — **Air Motor** features extra long stroke for powerful, uniform delivery on both up and down strokes. **Shovel-Type Foot Valve** adds mechanical priming to normal suction ... assures positive prime with all industrial lubricants even at lowest temperatures.

STURDY CONSTRUCTION — Plunger and Bushing of case hardened Nitraloy steel ... prolongs life ... resists wear. Pump Outlet Body of all steel, one-piece construction ... hydrogen brazed. Withstands constant pulsation and extreme pressure. All moving parts are of tough, heat-treated steel.

TROUBLE-FREE, POSITIVE PERFORMANCE — Air Motor operation is 100% pneumatic ... no springs to wear out, rust, or lose tension. Air Valve is stall-proof, leak-proof and prelubricated ... toggle action assures positive tripping.

HIGH EFFICIENCY — Advanced design, double-acting **mechanisms** assure dependable low surge operation with minimum air consumption. Large **air passages** allow unrestricted venting.

PRECISION MADE — All mating surfaces of plunger, Bushing and Air Valve are microlapped to high tolerance ... prevents by-passing lubricant or bleeding off air. No washers or packings to replace.

SIMPLIFIED MAINTENANCE — Modular design of **Pump Tubes** provides extreme ease of disassembly ... invaluable when using compounds which may "set up," such as paints, plastics, etc. Entire mechanism can be assembled only "hand tight" and function perfectly for an indefinite period. **Air Motor Piston** and **Cylinder** ... No oiling required ... minimum friction ... no leather cups.

LIGHT WEIGHT — Generous use of aluminum makes **Pump** amazingly light in weight and distributes heat to prevent "icing" of **Air Valve.**

QUIET OPERATION — Exhaust port is free-flow in design and shielded by sleeve to produce a natural muffling effect.

INDUSTRY-WIDE APPLICATIONS — **Five Pump Tubes** are available for the POWER-MASTER series providing 19 ratios from 2 to 1, to 75 to 1. Meets all Industrial requirements. Handles all materials, from light, volatile solvents to heavy mastics.

For complete information on the new Power-Master series, contact your nearest Lincoln distributor ... and write for new Lincoln Catalog No. 65.

Lincoln

NATIONAL OFFICERS

PRESIDENT

J. D. Lykins,
Wheeling Steel

V. PRES. AT LARGE

A. B. Wilder,
E. I. duPont

SECRETARY

J. L. Finklemann,
Cycleweld Corp.

TREASURER

J. W. Peterson,
Standard Oil (Ind.)

EXEC. SECRETARY

C. L. Willey,
ASLE National Office

CHRM. P. COUNCIL

J. O. McLean,
Reynolds Metal

REGIONAL VICE PRESIDENTS

WESTERN

R. C. Dishington,
Gen. Pet. Copr.

EASTERN

D. F. Wilcock,
General Electric Co.

CANADIAN

S. C. M. Ambler,
British Amer. Oil Co.

CENTRAL

P. A. Asseff,
Lubrizol Corp.

MIDWEST

H. W. McCulloch, Jr.
Shell Oil Co.

NATIONAL COMMITTEE CHAIRMEN

ABSTRACTS ..... W. E. Campbell, Afram Consultants
ANNUAL MEETING ..... R. C. Sager, Gulf Oil Corp.
ANNUAL MEETING SITES ..... L. O. Witzenburg, Farval Co.
AWARDS ..... E. R. Booser, General Electric Co.
BY-LAWS ..... A. E. Cichelli, Bethlehem Steel Co.
EDITORIAL ..... J. Boyd, Westinghouse Research Labs.
EDUCATION ..... M. E. Dougherty, Acheson Colloids Co.
FINANCE ..... C. C. Blaisdell, Penola Oil Co.
HANDBOOK ADVISORY .... C. R. Schmitt, E. F. Houghton & Co.
HISTORIAN ..... W. G. Fatch, U. S. Steel Corp.
INDUSTRIAL MEMBERSHIP ... C. L. Willey, ASLE National Office
JOUR. BEARING RESEARCH, E. M. Kipp, Aluminum Co. of America
LUBRICATION CONFERENCE, A. C. West, California Research Corp.
MEMBERSHIP & ADMISSION ..... B. M. Dunham, Sun Oil Co.
NEW SECTIONS ..... C. L. Willey, ASLE National Office
NOMINATIONS ..... J. O. McLean, Reynolds Metal Co.
PROGRAM ..... L. E. Hoyer, American Brake Shoe Co.
PROJECTS ..... E. S. Carmichael, Socony-Mobil Oil Co.
TELLERS ..... R. G. Grothus, Bell & Howell Co.

NATIONAL DIRECTORS

R. J. Torrens
Eastman Kodak Co.

D. M. Cleaveland
Bendix Avia. Corp.

E. E. Bisson
Nat'l Advisory Committee for Aer.

B. T. Harding
Midwest Oil Co.

B. G. Symon
Shell Oil Co.

D. W. Sawyer
Alum. Co. of Amer.

A. B. Two
Ford Motor Co.

L. O. Witzenburg
The Farval Co.

JOINT TECHNICAL COMMITTEES — A. E. Cichelli, Chairman; T. W. Havely, Vice Chrm.

TECHNICAL COMMITTEE CHAIRMAN

BEARINGS & BEARING LUBRICATION
L. E. Hoyer, American Brake Shoe Co.

ENGINE LUBRICATION
W. C. Witham, U.S.D.A. Northern Utilization R. & D.

FLUIDS FOR METAL WORKING
A. E. Baker, Jr., General Electric Co.

HYDRAULICS & HYDRAULIC MACHINERY
R. L. Leslie, Vickers Inc.

LUBRICANT RECONDITIONING & DISPOSAL
W. H. Craig, Sharples Corp.

LUBRICATION EQUIPMENT
T. M. Murphy, Alemite Div. Stewart-Warner Corp.

LUBRICATION FUNDAMENTALS
M. B. Peterson, General Electric Co.

LUBRICATION PRACTICES..R. H. Hendrick, Reynolds Metal Co.

PROPERTIES OF LUBRICANTS
J. F. Cook, Union Oil Co. of California

SEALS & PACKINGS
R. W. Himrod, Federal-Mogul-Bovar Bearings

JOINT INDUSTRY COUNCIL

INDUSTRIAL COORDINATOR.....T. F. Davidson, WADC
VICE CHAIRMAN...E. S. Reynolds, Socony-Mobil Oil Co., Inc.
AVIATION.....T. F. Davidson, WADC
MACHINE TOOLS..W. D. Whalen, LeBlond Machine Tool Co.
NATIONAL RAILROAD LUBRICATION COUNCIL
L. E. Hoyer, American Brake Shoe
TEXTILE.....J. K. Wilcox, American Viscose Corp.
STEEL.....A. C. Brownell, Bethlehem Steel Co.
NON-FERROUS METALS
L. H. Decker, Revere Copper & Brass, Inc.
PETROLEUM & CHEMICALS.....K. Borah, Shell Oil Co.
POWER.....E. S. Reynolds, Socony-Mobil Oil Co.
MINING.....C. D. Johnson, Erie Mining Co.

ACHESON

dispersions digest

Reporting uses for

dag® BRAND DISPERSIONS

COLLOIDAL GRAPHITE, MOLY-SULFIDE, VERMICULITE, AND OTHER SOLIDS

THE IMPORTANCE OF 'DAG' DISPERSIONS FOR ASSEMBLY AND RUN-IN

The advantages of using 'dag' dispersions for both assembly and run-in lubricant applications are vital to the useful operating life of machinery and engines. Dry lubricating films formed on friction surfaces with colloidal graphite in volatile carriers possess many desirable advantages; lower coefficient of friction, lower bearing temperatures, smoother run-in and reduced maintenance costs. Also, protection is afforded against momentary failure of the oil supply.

United Welding rebuilds more than 5000 diesel engine blocks and cylinder heads a year. After repairing and resurfacing, all bright metal parts must be protected against oxidation, foreign particle abrasion, and lubricated for re-assembly. One material performs all of these functions. 'dag' 154 — colloidal graphite in an isopropanol carrier — is mixed in a ratio of one part 'dag' 154 to nine parts alcohol and applied by spray to each completed unit. This tough, dry lubricating film has eliminated the necessity for a protective grease coating. Foreign particles cannot adhere to the film . . . even after a year in storage, all that is necessary is to blow the dust off the part with an air hose. Since degreasing is no longer required, a substantial savings in materials and labor is realized. During the subsequent run-in operation, the microscopically-thin film of graphite minimizes wear on newly machined surfaces. In addition, because of the much lower surface tension which exists between oil and a graphite surface, oil spreads more rapidly and over a greater area — thus permitting an oil film which has been broken to re-establish itself quickly. Results are longer periods of full film lubrication and, again, less wear. Trade publication reprints are available. Also, write for Bulletin 421 on 'dag' dispersions for assembly and run-in. Address Dept. LE-98.

A rebuilt diesel cylinder head is sprayed with 'dag' 154 as assembly lubricant at United Welding Processes, Inc.

Pre-assembly application of 'dag' 213 prevents piston seizure at Walter Kidde & Co.

Walter Kidde & Company manufactures a four-stage aircraft compressor, the heart of an airplane's pneumatic system. Absolute operational reliability must be guaranteed. Lives depend on it. Therefore, particular care is taken during run-in to insure the compressor's operation against the possibility of piston seizure. By applying 'dag' Dispersion No. 213 — colloidal graphite in an epoxy-resin solution — to the aluminum pistons before assembly, Kidde has solved this problem. The piston coating is applied by spray, then oven cured at 350° F. for 2½ to 3 hours. The result is a film which is hard, durable, and inherently slippery. During run-in the graphite works into the surface to become practically integral with the metal. The application of 'dag' colloidal graphite, together with their ultrasonic cleaning technique which prepares a cleaner surface beforehand, completely eliminates galling and seizure thus cutting rejects during break-in to 2%. Acheson dry film lubricants provide the answer to many such pre-assembly applications; surface protection against oxidation, aiding press-fits of cylinder liners into engine blocks, etc. Bulletin 435 on dry film lubrication and reprint MW, containing further information is available at your request. Or call in your Acheson Service Engineer.

ACHESON *Colloids Company*

PORT HURON, MICHIGAN

A division of Acheson Industries, Inc.

Also Acheson Industries (Europe) Ltd. and affiliates, London, England

50th ANNIVERSARY

Offices in: Boston • Chicago • Cleveland • Dayton • Detroit • Los Angeles • Milwaukee New York • Philadelphia • Pittsburgh • Rochester • St. Louis • Toronto

NEW PRODUCTS

LUBRICANT EASES ASSEMBLY OF TIGHT-FITTING PARTS

A new lubricant, used to facilitate the assembly of tight-fitting parts, threaded or otherwise, is applied by hand to the mating surfaces or by dipping or rubbing the lubricant into threads. Coating the pieces with the lubricant, Nolox G-707, reportedly permits precision pieces to be assembled and disassembled easily, even after high heat. The lubricant is said to be effective on all metals, including stainless steel, and has countless uses in assembly and disassembly of close tolerance parts in machine building, automotive, aircraft, atomic and automation industries, as well as maintenance of processing equipment in the chemical industry. A free trial sample of Nolox G-707 may be obtained by writing Anchor Chemical Company, 10721 Briggs Road, Cleveland, Ohio.

ALL-PURPOSE FERRITE MAGNETS

Permanent barium ferrite magnets for unlimited applications are now available.

The magnets are of the ceramic type and offer many features that reportedly benefit the user performance-wise and cost-wise. The magnets are smaller and lighter in weight yet do not sacrifice magnetic power. They contain no critical material, are non-conductive, will not rust and are chemically inert. They also offer greatest resistance to demagnetization, require no keepers or pole pieces, have best storage life and can be magnetized either before or following assembly of user's product. Inquiries, or prints and specifications for cost quotation should be addressed to National Moldite Co., 248 South St., Newark, 5, N. J.

OIL PRESSURE SYSTEM

A compact, ready-to-connect, circulating unit for maintaining controlled volume and pressure of oil for stuffing boxes has just been introduced under the tradename "CircOilator." Designed particularly for stuffing boxes containing double mechanical seals, it is also adaptable for conventional packings, bearings, and other hydraulic requirements. The system comes complete with 18-gallon tank, pump, motor, pressure regulator, filter, tank breather and relief valve as standard equipment. For further information write Durametallic Corporation, Kalamazoo, Michigan, requesting illustrated Bulletin No. 484.

HIGH PRESSURE FILTER

A new series of laminated fiber disc filters is now being offered by Wm. W. Nugent & Co., Inc. The new filters,

designated as 1555CP, are designed for hydraulic and other high pressure applications. They are constructed for 3000 psi working pressure to comply with the requirements of the ASME Code for Unfired Pressure Vessels. API or ASME code inspection and stamping is available. 1555CP filters are offered in five sizes with capacities ranging from 1.5 GPM at 3 psi pressure drop to 47.6 GPM at 6 psi pressure drop when filtering 100 SSU viscosity mineral oil. For larger capacities, the filters may be connected in multiple. Inlet, outlet, and drain are located in the bottom of the filter. Complete information on 1555CP Filters may be secured by writing Wm. W. Nugent & Co., Inc., 3440 Cleveland St., Skokie, Ill.

SUN OIL SULFONATE

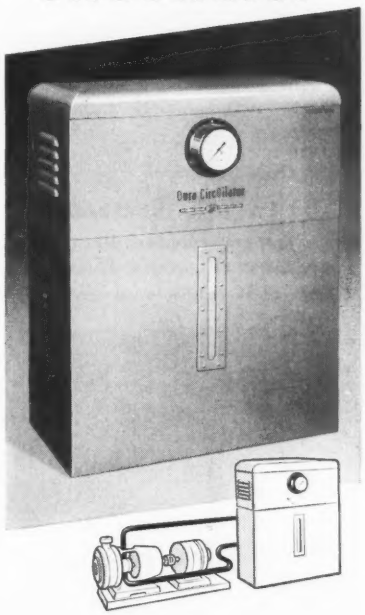
A new lighter-colored, oil-soluble sodium sulfonate is now available from Sun Oil Company's refinery at Marcus Hook, Pa. New sulfonate LC has a maximum ASTM (dilute) color specification of 3½ and is available in tank car and tank truck quantities. The new sulfonate is recommended for compounding emulsifying, dispersing, and wetting agents, rust and corrosion inhibitors, demulsifying agents, dry cleaning compounds, fat-splitting agents, flotation agents, fuel oil, grease, and lubricating oil additives, metalworking oils, textile oils and pigment dispersing agents.

GAS RESISTANT PACKINGS

A new line of gasoline resistant packings and gaskets for use in gasoline meters and other equipment handling

New . . .
Compact . . .
Ready-to-connect . . .

Dura CircOilator



A SELF-CONTAINED circulating unit, low in cost and easy to connect to existing equipment . . . for automatic control of volume and pressure of oil for stuffing boxes containing double mechanical seals or conventional packing. Also adaptable for bearings or other hydraulic requirements.

WRITE TODAY FOR BULLETIN NO. 484 to

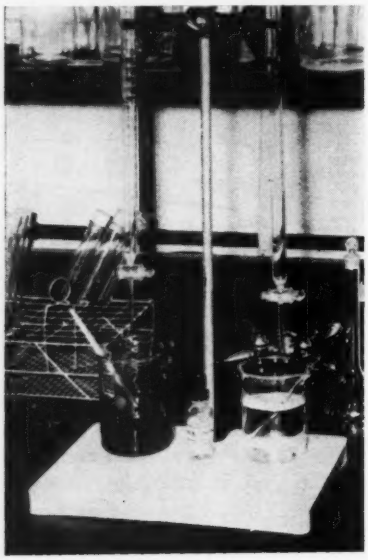
DURAMETALLIC CORPORATION

DEPT. LUB
KALAMAZOO, MICHIGAN

gasoline, naptha, etc., has been announced. Made of fine grade selected leathers with a special impregnation, these packings are for all practical purposes impervious to gasoline and thus eliminate swelling of the packings. The impregnation does not leach out of the leather. The packings are highly resistant to abrasion and give long life and cutting maintenance costs. The new gasoline resistant packings are available in cups, vees, flanges and other standard types as well as in die cut gaskets. For full information write R. A. Waterfield, Manager Packing Sales, Page Belting Co., 80 Bell St., Concord, N. H.

NEW TITRATION BASE

A new polyethylene titration base, adaptable to all sizes of standard ring stands, has been developed recently. An



important advantage of this new titration base is its portability which allows it to be used in conjunction with any existing ring stand, and also provides for maximum ease of cleaning. The polyethylene base is large enough in surface working area to provide ample space for beakers, glass, titration indicators and other accessory equipment. It is provided with a lip around the entire top surface of the tray to prevent spillage of corrosive reagents, with a white pigment to furnish a background conducive to maximum ease of endpoint determination. In addition to being completely corrosion resistant, even to hydrofluoric acid and strong caustics which may attack porcelain bases, it furnishes outstanding resistance to fracture and chipping. The surface of the polyethylene, which is more resilient than that of porcelain, also tends to reduce breakage of glass equipment which may be bumped accidentally against the base. Further information on this new polyethylene base may be obtained from American Agile Corp., P. O. Box 168, Bedford, Ohio.

AIR CYLINDER OPERATOR

Worcester Valve Co., Inc., has introduced its new air cylinder operator, designed specifically for use with the Cono-

o-"miser" ball valve. This time-saving air cylinder can be mounted on either side of the pipe and on either end of the valve. One or more valves can be controlled manually or electrically from a central location, depending on requirements and specifications. Manual operation of the valve is possible in the event of air or electrical failure. For detailed information write Worcester Valve Co., Inc. 16 Parker St., Worcester 10, Mass.

PILLOW BLOCK BALL BEARINGS

Introduced by the Fafnir Bearing Company, New Britain, Connecticut, the new

standard series LAKH pillow block ball bearing has been designed to meet specific customer requirements for varying overall dimension. The new LAKH is self-aligning in any direction and can be installed immediately.

YOUR LUBRICATION PROBLEM IS OUR BUSINESS

Call in one of our specialists!

Contact the nearest member or representative of the Far-Best Group when you need:

Cutting Oils
Tapping Compounds
Drawing Compounds
Rolling Oils
Metal Cleaners
Sulfonated Oils
Heat Treating Compounds
Grinding Coolants
Rust Preventatives
Lubricant Greases
Lubricant Additives
Motor Oils
Specialized Lubricants
Lanolin
Industrial Soaps
Laundry Products
Sulfurized Oils

The Far-Best Corporate Group includes:

- **Allube Corp., 928 Allen Avenue Glendale, Calif. Chapman 5-1158**
  —33 years manufacturing experience
- **Far-Best Corp., 6715 McKinley Ave., Los Angeles, Calif. Pleasant 8-3181 and 2800 Commerce St., Franklin Pk., Ill.**
  —26 years manufacturing experience
- **O. L. King & Co., 782 Minnesota Street, San Francisco, Calif. Valencia 6-6701**
  —26 years manufacturing experience
- **Dacus Oil Corp., 782 Minnesota St., San Francisco, Calif. Valencia 4-5185**
  —25 years manufacturing experience
- **Sanford Process Corp., 6920 S. Central Ave., Los Angeles, Calif. Ludlow 3-4856**
  —10 years development and production experience

A total of 120 years' industrial experience in solving production and maintenance problems.

REPRESENTATIVES

Peacock Supply Co.,
Salt Lake City, Utah

Pacific Machinery & Tool Steel,
Portland, Oregon

Carl F. Miller Co.,
Seattle, Washington

Far-Best, Inc.,
Aiken, South Carolina

Lube Lines

by A. F. Brewer*

Profit From Records

The dictionary identifies profit in a variety of ways, viz: To use to advantage, to gain, the excess of return over expenditure, to improve, to become proficient. The latter relates to lubrication. The end result is definitely tangible, very often it can be expressed as a monetary value. It all depends upon how the translation is obtained. Records "before and after" will prove the point if more effective lubrication leads to greater economy of lubricants, lower maintenance costs, longer machine life, greater safety or increased production.

More and more operators of machinery are becoming record conscious. Where lubricants and lubrication are involved, records must relate the machine to the lubricants required, to the specific service of the operating mechanisms, to the time element and to the available means of lubricant application.

Records may be kept in a variety of ways. In reality their presentation can reflect the personality of the personnel as well as the machine. They can be simplified or quite detailed. Realizing the demands upon the time of those responsible for keeping records, simplification is desirable to forestall the temptation to "fudge." Then the resultant data can be most profitable. The following tabular arrangements can be useful in this regard.

TABLE 1. Lubrication Record

MACHINE. IDENTITY, WITH LISTING OF OPERATING PARTS	TYPE OF LUBRICATION	LUBRICANT TYPE OR GRADE	RE-LUBRICATION PERIODS	FREQUENCY OF INSPECTION
Bearings.				
Sleeve-type				
Ball				
Roller				
Gears				
Enclosed				
Exposed				
Chains				
Enclosed				
Exposed				
Wire Rope				
Couplings				
Cams				

TABLE 2. Lubricant Consumption—Monthly

Name of Machine_____

PRODUCT OIL OR GREASE	VOLUME CHARGED OUT FROM OIL HOUSE OR STORAGE		COST	
	POUNDS GREASE	GALLONS OIL	PER POUND OR GALLON	TOTAL COST OF LUBRICANTS USED FOR PERIOD INDICATED.

TABLE 3. Lubricant Inventory as of_____

PRODUCT OIL OR GREASE	VOLUME ON HAND AS OF DATE	SUPPLIES RECEIVED	TOTAL FOR PERIOD INDICATED	VOLUME CHARGED OUT FROM STORAGE	VOLUME CONSUMED FOR PERIOD INDICATED

TABLE 4. Total Cost of Plant Lubrication—Monthly

Cost of lubricants consumed (from Table 2)	
Labor charged to lubrication department	
Supervision	
Maintenance of lubricating equipment	
New lubricating equipment	
Storage charge.	
Total	

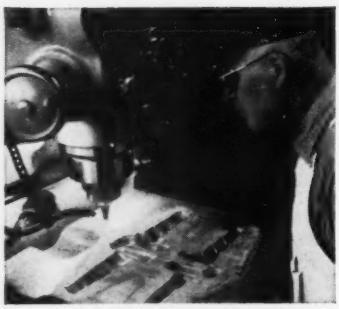
Managerial Responsibility

This requires complete cooperation between the front office and the lubrication personnel. When management provides adequate facilities for keeping lubrication records and appreciates that time is required to do a conscientious job, the prospective profits are obvious in the form of lower maintenance costs, greater safety of personnel and longer machine life. Manufacturing costs also become more realistic when related to lubrication data based on factual records.

* Consultant and author of "Basic Lubrication Practices"

Interstate Drop Forge Company—

20 Years a Cities Service Customer and Still Forging Ahead!



The modern way to cut a die is typified by die sinking machine, one of many at Interstate Drop Forge Company. All die sinking machines are lubricated by Cities Service lubricants.

With production running at roughly 1000 tons per month, Interstate Drop Forge Company of Milwaukee is one of the largest forging concerns in the Wisconsin area and growing all the time.

An integral part of this growth story, Cities Service is proud to have filled Interstate's lubrication needs for the past 20 years.

Drop hammers... helve hammers... upsetters . . . forging rolls . . . shapers . . . automatic metal saws. These are but a few of the diversified machines lubricated by specially tailored Cities Service oils and greases.

Actually, in a plant of this type with so many differing pieces of machinery, it would be possible to have as many as 25 different lubricants. But, Interstate, with the aid of their Cities Service Lubrication Engineer has been able to standardize on twelve Cities Service lubricants.

Streamlining . . . standardizing . . . improving. These are some of the services a Cities Service Lubrication Engineer can render for your operation, too. Ask him to make a free lubrication survey of your plant. Call the nearest Cities Service office or write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

Vol. 14, No. 9

Lubrication Engineering

september stirrings

Well, the old boat's been put into drydock to await another summer and the old fishing pole has been shoved into a closet somewhere, not to emerge 'til next spring. The leisurely pace of summer has been tossed aside and frenetic activity is stirring on all sides.

. And our Society members are right in the midst of the fall whirl. One of the first signs of renewed Section activity that drifted across our desk contained an announcement of a Chicago Section-sponsored educational course on problems dealing with practical lubrication, beginning October 6. Other announcements were snowing down on us thick and fast by the time we went to press.

The Gear and Gear Lubrication Committee is busily organizing a Gear Conference scheduled for January 26 and 27, 1959. A new and so-far untried venture that promises to be of a very timely and informative nature.

Then there's a big project slated for October 13 through 15 of this year —the ASLE-ASME Joint Lubrication Conference in Los Angeles. This is the fifth time that the two societies have cooperated in this project. The family-vacation-spot atmosphere of the Los Angeles area has led the conference planner to provide a Ladies Program that includes trips to Disneyland and Knotts Berry Farm as well as tours of Marineland and the Los Angeles Coliseum—home of the LA Dodgers. It's hoped that many members and their families will take advantage of this double-pronged opportunity to soak up information and sunshine at this year's Joint Conference. The papers to be presented are in tune with the space age in which we've suddenly found ourselves—in fact, an entire session is devoted to aircraft and missile accessory lubrication problems.

A good way to start off the fall season would be through having a well-attended Lubrication Conference. So for an informative and thought-provoking session, we'll see you in Los Angeles.

J. D. Lykins

Economics of Oil Reclamation for Railroad Equipment

*by T. W. Potter**

The first fifty years of railroading was a period of development in design of the journal box assembly for railroad equipment. Realizing the necessity for a standard design so that the equipment could be used in interchange, the railroads in 1874 adopted the assembly now used.

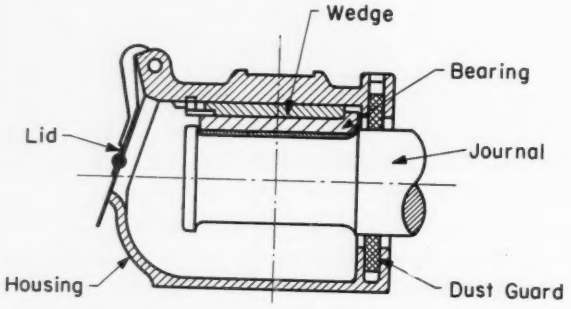


Figure 1. Section drawing showing main parts of a plain bearing railroad journal box.

The box which houses the journal, bearing and wedge, also serves as a reservoir which holds the lubricating oil and wicking medium. Reclamation of this oil and wicking medium is the subject of this article.

AMOUNTS OF LUBRICATION MATERIALS

There are approximately 15,000,000 journal boxes using oil lubrication in service on American Railroads. Each box averages approximately 7 lb of oil and 2 lb of wicking material, a total of 14,000,000 gallons of oil and 30,000,000 lb of wicking material. The present standard practice is to remove the oil and wicking material from the freight cars each 18 months for reclamation. Removal takes place more often on other equipment. Equipment operating in flood and dust storm areas has to be repacked when excessive contamination is detected. The wicking material and oil content of the journal boxes are removed when inspection determines excessive contamination, and at specific intervals of time. The material is placed in barrels and shipped to the reclamation plant. The wicking material, cotton or wool threads, or a manufactured lubricator, including the oil and contamination is weighed upon receipt at the reclamation plant.

A breakdown of the materials received in the average 100 lb weighed in, is as follows:

Wicking Material	21 lb
Oil	69 lb
Water, Dirt & Other Contamination	10 lb

PURPOSE OF RECLAMATION

To illustrate the purpose of reclamation of car oils and waste, the following statistics are given for one reclamation plant for 1956:

Contaminated wicking material (cotton thread waste) and oil received for reclamation	6,365,279 lb
This contained approximately:	
Oil (577,000 gallons)	4,392,036 lb
Contamination (dirt, water, etc.)	636,527 lb
Wicking material (cotton thread waste)	1,336,707 lb
Total gallons of oil to be reclaimed (dirty)	1,032,967 gal*
Total gallons of oil reclaimed to specification	977,287 gal
Reclamation loss, water, dirt, etc.	55,680 gal
Percent of recovery	94.6%
Total required of this plant, including new material to make volume needed (oil or waste)	7,408,250 lb
Reclaimed oil and waste	5,313,768 lb
New wicking material (waste)	453,277 lb†
New oil required (218,827 gallons) or	1,641,205 lb†

* Journal Box Servicing Corp.

* Because of the use of clean oil to clean the wicking material, the volume of oil reclaimed during the processing is approximately double the volume of dirty oil received in dirty wicking material.

† Both new waste and new oil were required because the amount of lubricating material needed was in excess of the material available.

Figure 2. Outside view of a reclamation plant.

Using 1956 costs for new materials, the volume of lubricating material, waste and oil, supplied by this plant is valued at $888,990. Reclamation cost for dirty oil and waste, plus the cost for new material required was $270,443. Considering costs of lubrication material only, the reclamation reduced the cost per one thousand car miles, from 8.8 cents to 2.7 cents, a savings of 6.1 cents per one thousand car miles. Applying this savings to all oil lubricated car equipment on American railroads, the savings would be approximately $24,400,000. Therefore, it is quite apparent that oil and waste reclamation is a very important part of railroad economics.

WHAT IS EXPECTED

Association of American Railroad specification for journal box oil is rigid, being the same for new or reclaimed oil, and must conform to the following properties:

1. Flash-Minimum	350°F.
2. Saybolt Universal Viscosity at 210° F.	53–58 seconds
3. Viscosity Index	100 minimum
4. Pour Point, Upper Maximum	−20° F.
5. Moisture, Maximum	0.10%
6. Pentane Insolubles	0.15% maximum
7. Acidity—Neutral to Methel Orange and Phenolphthalein	

While the methods by which the specification is maintained through reclamation can be explained rather simply, variation of the process to any appreciable degree can result in oil which is rejected and must be re-entered into the equipment for further treatment.

METHOD OF OIL RECLAMATION

The oil reclamation is accomplished in closed tanks of approximately one-third greater capacity than the volume of oil to be treated. The addition of a solution containing sodium silicate and a solution containing sodium aluminate at the proper times during reclamation brings about the creation of gelation. The molecules of this gelation coalesce to miscelles and, with the addition of moisture, heat and pressure, utilized at the proper timing, the gelation is converted to zeolite. The zeolite crystallizes, trapping all solids in the crystallized gel, and precipitates rapidly. The clean oil is drawn off and pumped to storage tanks. The precipitant then goes through a water separator where traces of oil are removed. The oil then goes to tanks where additives may be added or the viscosity may be changed, if so desired.

For those interested in spectrographic analysis, an analysis on a typical sample of journal box oil before and after treatment is as follows:

	Dirty	Clean
Lead	3000 plus	55
Iron	235	12
Copper	135	53
Silicon	42	8
Aluminum	15	0
Silver	5	0
Tin	42	5
Calcium	75	0

The small amount of water in the dirty oil was completely removed during reclamation.

RECLAIMING OF WICKING MATERIAL

The Association of American Railroad specifica-

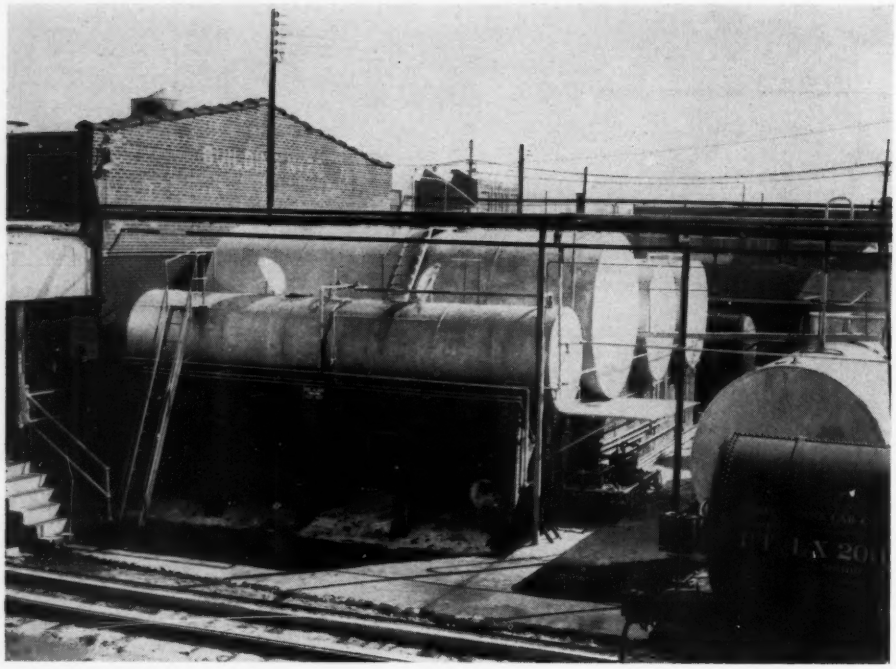


Figure 3. Overall view of oil treatment tanks.

tions of properties for renovated journal box packing are as follows:

Items	Packing
Clean Dry Waste	20–30%
Tarry Matter	0.15% maximum
Insoluble Impurities	2.0% maximum
Moisture	2.0% maximum
Oil	Balance

Note: Threads four inches or less in length shall not constitute more than 10% dry waste by weight of the clean dry waste.

Cotton thread waste is reclaimed by washing it in oil, maintaining a temperature of 260°F., mechanically passing it from one machine to the next while agitating, and a counter-current of clean oil over flows from one machine to the next, through a total of three baths.

Manufactured lubricators are reclaimed in just about the same manner, although repairs are often needed to place the lubricator in condition to return to service.

A ten year record of journal box packing recovery

(*Cont. on p. 404*)

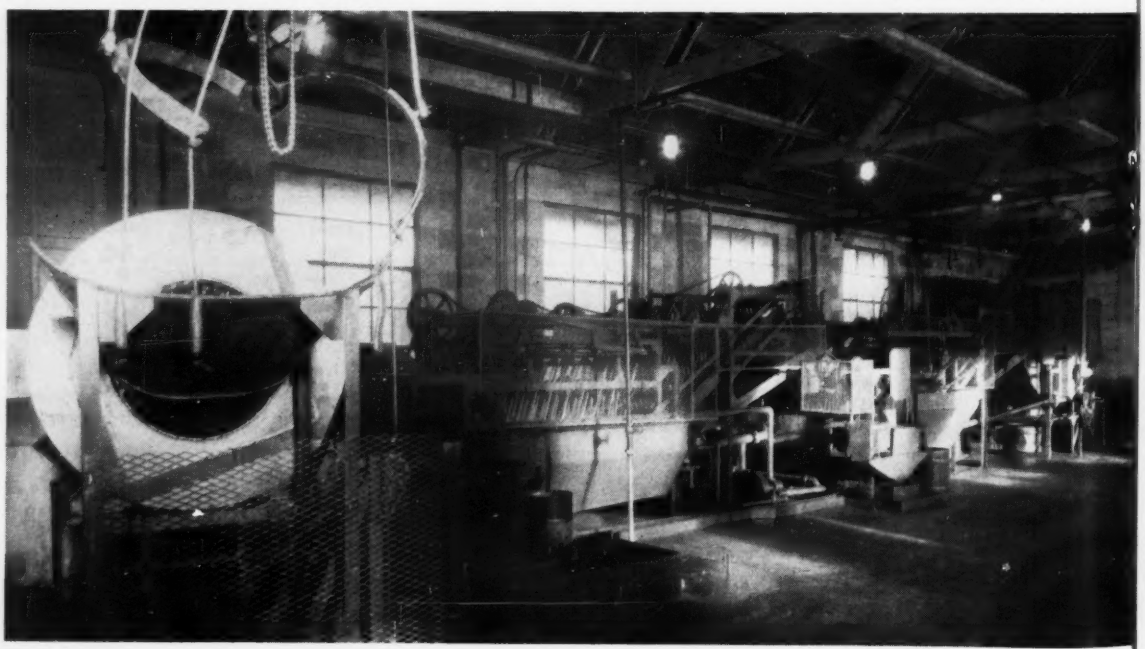


Figure 4. View of renovating machine used for washing waste.

Emulsion Type Fire Resistant Hydraulic Fluids

New Developments Reflect Improved Performance

C. E. Francis and R. T. Holmes***

Field experience has shown a water-in-oil emulsion to be satisfactory as a fire resistant hydraulic fluid for industrial applications. Information obtained from both commercial operations and laboratory experiments with respect particularly to the properties of viscosity, emulsion stability and wear have resulted in an improved formulation. These characteristics as well as others pertinent to the performance of a hydraulic fluid are discussed.

INTRODUCTION

The characteristics and performance of two types of fire resistant hydraulic fluids for industrial applications have been reported (1, 2). Both fluids have been available commercially for several years. One type is based on organic phosphates which are inherently fire resistant. The other is based on the solution of organic oxide polymers in glycol-water. The latter is termed a water-base or "snuffer-type" fluid and derives its fire resistance from the formation of a steam blanket upon contacting an ignition source.

Approximately two years ago a third fire resistant fluid, also a "snuffer-type," was introduced. This fluid was a water-in-oil emulsion. Laboratory data (3) showed this product to be satisfactory with respect to fire resistance, foaming and compatibility with seals and metals commonly employed in industrial hydraulic equipment. Its emulsion stability, viscosity, and lubricity were believed acceptable. However, its lubricity in some applications might be inferior to that of conventional fluids. The limited field information available confirmed laboratory results.

Subsequently, use of the emulsion-type fluid has been greatly extended and much has been learned about its performance in commercial operations. In some cases, this information has been qualitative, but some quantitative evaluations have been obtained through the cooperation of die-casting concerns. The latter results have been especially valuable since the die-casting of hot molten metals represents one of the most severe applications of hydraulic fluids. As a result of these observations, the formulation of the original water-in-oil emulsion was revised, leading to improved performance both in the laboratory and in the field. This article will present information on the laboratory evaluations and field performance of both the initial and revised versions will be presented.

DISCUSSION

VISCOSITY

The emulsion type fluid was initially developed with an equivalent Saybolt viscosity of 250 sec at 100°F and at a shear rate of 10,000 sec^{-1}. This value was selected to satisfy the bulk of the requirements with respect to viscosity for both single and dual stage hydraulic pumps. It also effected a compromise between the requirements for fire resistance, emulsion stability and viscosity. However, due to the non-Newtonian character of emulsions, the viscosity at low shear rates (less than 10 sec^{-1}) was about 400 ssu at 100°F which is somewhat higher than the values of 150-315 ssu at 100°F generally applicable to the conventional petroleum fluids. The higher viscosity of the emulsion required that the restrictions on the pump suction be maintained at a minimum to avoid cavitation on cold start-up. Although this qualification has been generally acceptable in practice, efforts were made to improve viscosity characteristics. That this has been accomplished is shown by Figure 1 in which

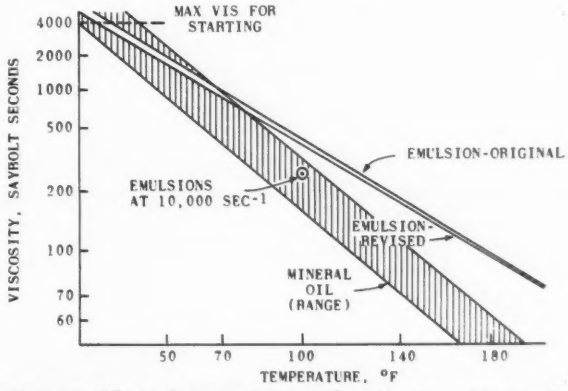


Figure 1. Effect of temperature on viscosity of emulsions and mineral oil at low shear rate

* Shell Oil Company, P. O. Box 711, Martinez, California

** Shell Oil Company, 100 Bush Street, San Francisco, California

viscosity changes are related to those of temperature. At 100°F, the revised fluid has a low-shear viscosity about 50 ssu below that of the initial formulation. At 40°F, the improvement amounts to 650 ssu. Further, the temperature at which the revised fluid possesses the commonly accepted "start-up" viscosity of 4000 ssu, is 25°F, a reduction of 5°F. The change in viscosity/temperature properties should be a factor in the demonstrated improvement in the wear performance of the revised emulsion.

The reduction in low-shear viscosity of the emulsion was accomplished without changing its "working" or high shear rate viscosity. Thus, the value applicable to both compositions at 100°F and a shear rate of 10,000 sec^{-1} is the equivalent of 250 ssu. Figure 1 shows that this value is within the range of viscosities of conventional mineral oil hydraulic fluids at this temperature.

In practice, hydraulic fluids should not show a marked deviation from their initial viscosity during usage. In the case of water base fluids, viscosity will vary with water content. For a water-in-oil emulsion, the viscosity will decrease as the water content is decreased. However, the emulsion viscosity will never drop below that of the oil component thus assuring satisfactory lubrication.

Considerable information has been accumulated on the performance of emulsion fluids with respect to viscosity stability. Periodic analyses have been made on used emulsion samples from various die-casting systems. These observations have, in some instances, covered a period of 1½ years. Representative data are shown in Figure 2.

In the case of the original composition, the viscosity of the samples obtained during the first few weeks of operation was lower than that of the emulsion as manufactured. The viscosity of the material immediately after being charged to the system was not available. Subsequently, the viscosity increased to approximately its value at the time of manufacture, at which point it essentially has remained for over one year. It is significant that during this extended period in which viscosity stability was maintained, "make-up" of the water content of the emulsion was not required.

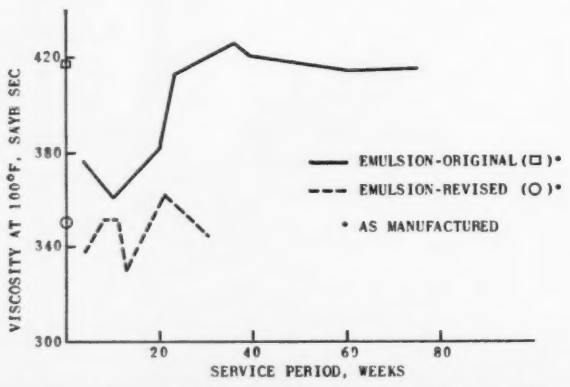


Figure 2. Effect of service period on the viscosity of emulsions

Data on the revised composition are not available for such an extended period. However, over an operating period of thirty weeks, viscosity remained sensibly constant between 330 and 360 ssu at 100°F. It is highly probable that its performance over extended periods will parallel that of its predecessor.

EMULSION STABILITY

Ideally, an emulsion to be suitable as a hydraulic fluid should show neither phase separation nor sedimentation of the dispersed phase. An approach to this condition is obtained in very viscous emulsions. However, it is difficult to prepare a completely stable water-in-oil emulsion having a viscosity in the range common to the conventional fluids. Furthermore, the preparation of a stable emulsion, even of proper viscosity would not be advisable since the difficulty of re-emulsifying water, which may be required as make-up to compensate for evaporation loss in service, increases as emulsion stability increases. Therefore, the initial composition exhibited some tendency for oil separation in static storage although water separation did not occur over a period of many months. This condition has been acceptable in practice since remixing of the continuous phase (oil) was readily accomplished by moderate agitation of the container before placing the fluid in a hydraulic system.

Aside from tests in laboratory rigs, considerably less was known about emulsion stability under dynamic (operating) conditions. Much information on this factor, however, has been accumulated during the past two years. In general, the performance of the emulsion in this respect has been satisfactory. In those few instances where phase separation has occurred, it has been attributable to contamination, chiefly by synthetic fluids, with which the emulsions are not compatible.

The samples of used emulsions discussed in the preceding section were examined in the laboratory for emulsion stability. This was done by storing graduated cylinders of the used fluid at 140°F and noting the rate of separation of both oil and water. The results of such a series of tests showing oil separation after seven days at 140°F are presented in Figure 3. They show that, in this accelerated test, oil separation was markedly greater for the used samples of the initial emulsion during the first few weeks of operation than at the time of manufacture. As the operating period lengthened, stability improved and reached a level at which it has remained for an overall operating period of 1½ years. Similar tests on the revised composition cover a shorter operation period but they indicate it to have a markedly greater emulsion stability in commercial service. Thus, in a series of seven samples taken during a period of thirty weeks, none showed a separation of oil or water greater than 3 percent, including those representing the initial period of operation.

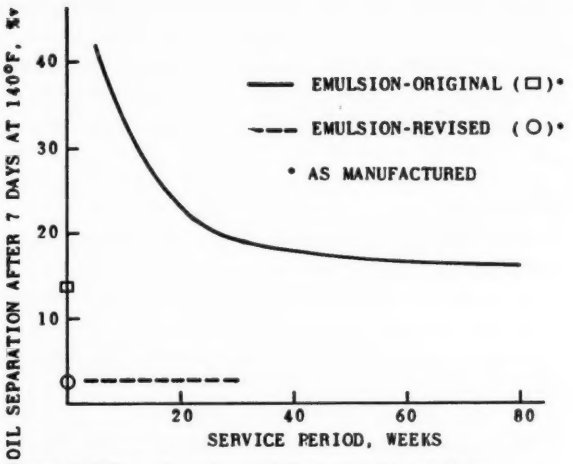


Figure 3. Effect of service period on emulsion stability

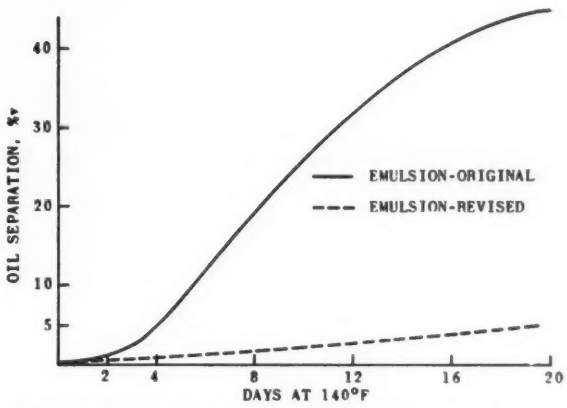


Figure 4. Stability of emulsions in static storage at 140°F

Figure 4 compares the emulsion stability in the 140°F test of the two versions at the time of manufacture. It illustrates the marked improvement that has been accomplished in this property.

Since the emulsion contains 40 percent water, it could be expected that it would be adversely affected by subnormal temperatures. Instances of phase separation were actually encountered under subfreezing conditions with the original emulsion. However, both laboratory and field tests have shown that the emulsion can withstand severe fluctuations in temperature. For example, five gallon containers of various emulsions, including the original and the revised formulations, were placed in unprotected storage at Reno, Nevada during the latter part of January 1957 for a period of 125 days. During this period the samples were exposed to 90 cycles in which the temperature decreased to less than 32°F. The lowest temperature reached was O°F and the longest continuous cycle in which the temperature was always below 32°F was about 100 hours. Examination of the samples at the close of the test showed no more than a trace of free water in any sample. In the case of the prior formulation, a slight amount of free oil was present. The exposure conditions in this test were not the most severe under which the fluids might be stored, but the results present evidence that the emulsions can withstand a considerable amount of subfreezing storage.

OXIDATION STABILITY

The operating life of a hydraulic fluid is highly dependent upon its ability to resist oxidation. Various empirical test methods have been designed for the determination of the oxidation resistance of oils. The ASTM Method D-943, "Oxidation Characteristics of Inhibited Steam Turbine Oils," commonly known as the Turbine Oil Stability Test (TOST), has frequently been used for the examination of conventional hydraulic fluids. It is also suitable for testing the emulsion fluids if modified slightly by omitting the initial addition of water. The stability of both versions of the emulsion fluid as determined by this procedure is illustrated by Table 1. These values show that the revised formulation has a "life" of over 1,000 hours which is equal to the stability of a high quality steam turbine oil.

Additionally, oxidative stability of the revised composition has been evaluated in the apparatus specified by the former Method 345 of the Federal Specification VV-L-791, commonly known as the "Work Factor Test." In this test, the fluid "lubricates" a 6-inch steel journal revolving at 3000 rpm in a babbit bearing loaded to 150 psi. The apparatus was modified in that an external reservoir holding four gallons of fluid was employed. Bearing temperatures were about 190°F and sump temperatures were 140 to 150°F during the test period of 1175 hours. Water lost from the emulsion by evaporation due to the high bearing temperature was replaced on a four-hour schedule. The total water replacement for the entire test amounted to 500 percent of the water content of the fresh emulsion. Despite these severe conditions, the emulsion at the conclusion of the test showed no appreciable change in quality. No evidence of oxidation of the oil phase, as measured by an increase in acidity, was apparent.

In commercial practice, acidity determinations have been employed to follow oxidative changes in the

TABLE 1 Oxidation Stability* of Emulsion Fluids

Test No.	Time to develop acidity (TAN-C) of 2.0 mg KOH/gm, hr		
	1	2	AVER
Initial Composition	450	380	415
Revised Composition	1010	1050	1030

*ASTM Method D 943 (modified)

emulsion fluid. Referring again to the die casting operations, samples taken after 75 weeks operation on the earlier emulsion composition and after 30 weeks, on the revised emulsion possessed no greater acidity than when charged to the equipment. Since the laboratory oxidation test showed the new composition to have a stability 150 per cent greater than the initial composition, it appears that the field performance of the new fluid should be fully satisfactory with respect to oxidation stability.

FILTRATION

Limited information concerning the effect of pressure side filters on fluid quality was available for the first report (3). The conclusion at that time was that quality was depreciated if filters of fine porosity or absorptive type filters were employed. This led to the study of a wide variety of filters in the laboratory. A bench test was designed in which the emulsion, maintained at 150°F, was continuously recirculated through the various filters. Periodic observations were made of fluid quality and of any tendency toward filter plugging as measured by line pressure and fluid flow rate.

In the most recent of these tests, the revised emulsion was recirculated through a 30-micron screen-type filter for a total of 120,000 cycles (2200 hours). No significant increase in line pressure or decrease in fluid flow rate was noted and fluid quality was not adversely affected. By contrast, the emulsion stability of the earlier composition was depreciated after 20,000 cycles through a 36-micron metal-edge filter. Even so, if the latter value is transposed to a commercial operation using a 10 percent by-pass filter attached to a system holding 150 gallons of fluid being circulated at 50 gallons/minute, 10,000 hours would be required to cycle the contents 20,000 times. However, such a comparison is not straightforward since it does not account for the possibility of increased solids retention per unit area of the filter due to the greater volume of fluid circulated, and the consequent effect on filtration. The laboratory results, though, do show that the new composition is more amenable to filtration. Filter types of even lower porosity are being studied.

Thus far, the experiments have indicated that the use of adsorptive (clay-packed) filters would be detrimental. This type of course, is generally not recommended for inhibited or additive type oils. No conclusion can be made on absorptive filters, e.g., cellulose packed, since they have not received sufficient study. Mechanical metal filters, such as screens and edge-plate filters, appear to be satisfactory down to a pore size of at least 35 microns. Further, it is known that sintered metal elements having a pore size of 20 microns are being used satisfactorily in portable filters for periodic filtration of the emulsion fluid.

Wear debris is not completely removed by filters. For example, in a laboratory application employing a full flow, pressure side, sintered metal filter having nominal pore size of 5 microns, only 50 per cent of the debris resulting from the wear of steel pump parts was removed. Greater use is being made of magnetic plugs correctly located in fluid reservoirs for the removal of submicronic particles. It has been shown (4) that pump service can be materially extended in this manner.

WEAR

Aside from the ability of fire resistant fluids to resist ignition, the ability of the fluid to prevent wear is of major importance to the user. The assessment of wear can be accomplished in many ways. Thus, numerous laboratory bench tests, such as the Timken Extreme Pressure test, the Almen Wear test and the Shell Four Ball Wear test, afford a measure of wear. The results may or may not correlate with practice. In the case of hydraulic fluids, a closer approach to the determination of wear under field conditions can be had by using commercial scale pumps in laboratory tests. Ultimately, however, it is necessary to examine the performance of a fluid in commercial hydraulic systems.

The information which was published (3) earlier on the subject of wear in hydraulic pumps operating on emulsions was based largely on laboratory studies. The data indicated that wear with the water-in-oil emulsions was of the same order as with the conventional mineral oils. Commercial experience has substantiated this conclusion in some instances but in others the emulsion fluid has not equaled the wear performance of the mineral oils. This difference is due to several factors. Operating conditions, such as pump type, starting temperature, operating temperature and pressure restrictions on pump suction, loading cycle and system cleanliness, markedly influence fluid performance. Further, quantitative wear measurement under strictly repeatable conditions are difficult to obtain in commercial systems. As a result, opinions vary as to the "wear life" to be expected from conventional fluids and values from 2000 to 10,000 hours have been mentioned.

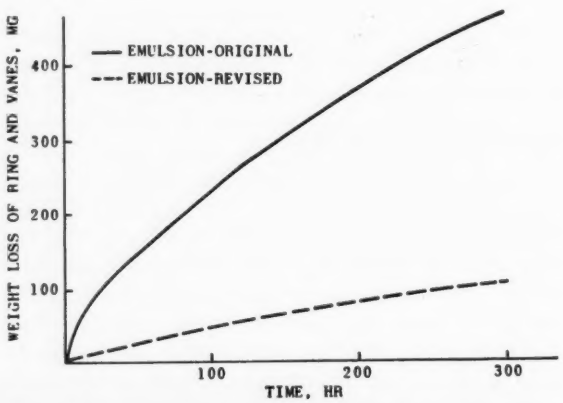


Figure 5. Performance of emulsions in constant volume vane-type pump at 1000 psi and 150°F

Laboratory rig tests have been continued as screening tests on alternative compositions. In most experiments, a 1200 rpm, constant-volume (5 gallon) vane pump was employed. The fluids were maintained at 150°F and continuously circulated through a pressure control valve at a pump discharge pressure of 1000 psi. Pump wear was measured periodically over a total operating time of 300 hours by determining the weight loss of the pump parts. Figure 5 shows the marked improvement in wear performance in this test afforded by the revised composition.

Additionally, the current product has been examined in a laboratory rig using a variable volume vane pump. In this case, the fluid temperature was maintained at 120°F, the total operating time was 1000 hours and the pump was operated at the following 36-second cyclic procedure which typifies many commercial conditions:

a. 12 sec at low pressure and full flow,
b. 12 sec at 600 psi and partial flow, and
c. 12 sec at 1000 psi and no flow.

Wear was again assessed by the periodic determination of weight losses of pump parts. The wear/time curve for the vanes and ring is shown in Figure 6. Wear rates for both the ring and vanes decreased as the test progressed. The rotor, port plates, bronze bushings and shaft were in excellent condition at the close of the test. Photographs of the ring, vanes, shaft and bushing (head end) are shown in Figure 7, 8, 9, and 10, respectively.

With respect to commercial operations, the quantitative evaluation of wear for the emulsion fluids, both old and revised, can best be presented by comparing their performance in two metal die casting machines. Both machines are identical in make and capacity and were operated under similar conditions of pressure and temperature. Both employ a vane type shot pump and a vane type dual die pump. The high pressure section of the dual pump is identical to that of the shot pump, both being subjected to cyclic pressure demands of 1000-1200 psi. New, pre-weighed pump parts were installed during a normal plant shut-down. These

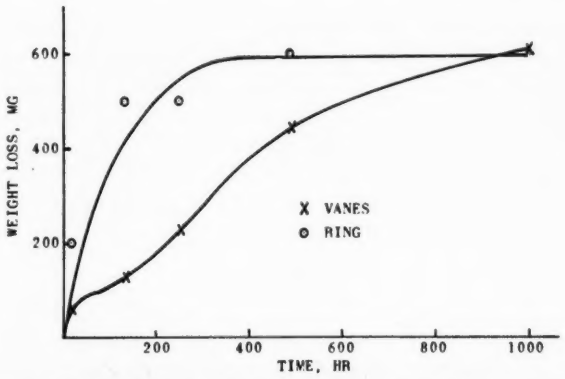


Figure 6. Performance of revised emulsion in variable-volume vane-type pump under cyclic conditions and at 120°F

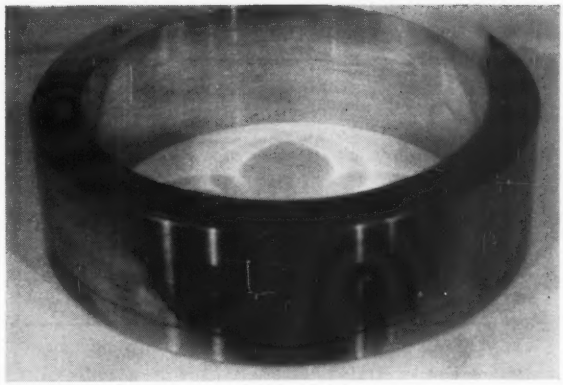


Figure 7. Ring from 20 gal/min variable-volume vane pump after operating on revised emulsion for 1000 hours

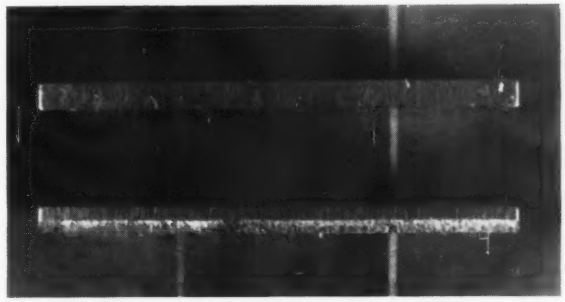


Figure 8. Vanes from 20 gal/min variable-volume vane pump after operating on revised emulsion for 1000 hours

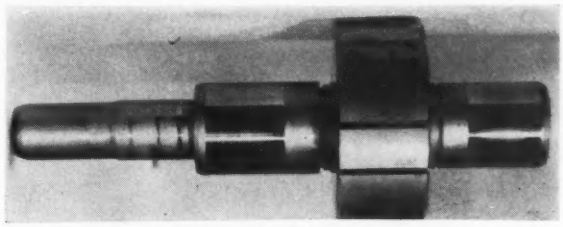


Figure 9. Shaft from 20 gal/min variable-volume vane pump after operating on revised emulsion for 1000 hours.

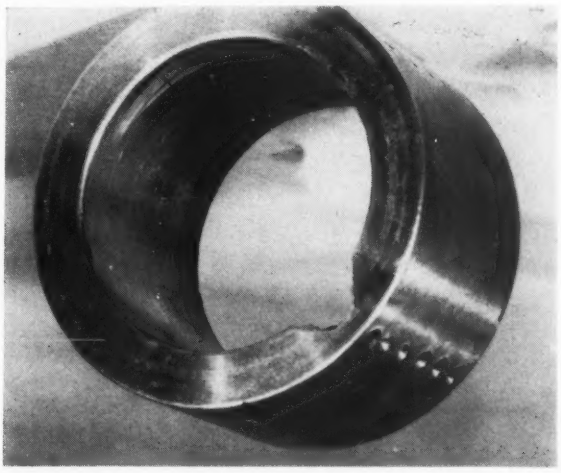


Figure 10. Bronze bushing from 20 gal/min variable-volume vane pump after operating on revised emulsion for 1000 hours

TABLE 2 WEAR PERFORMANCE* OF EMULSIONS IN COMMERCIAL SCALE DIE CASTING OPERATIONS

EMULSION	ACCUM OPER TIME, HR	WEAR RATE, GM/1000 HR	
		VANES	RING
1. Original Version	2750	3.76	2.64
2. Revised Version	2890	3.19	0.59
Improvement (2 OVER 1), %	—	15	78

*In constant-volume, 10 gpm vane pump

were inspected and reweighed during a subsequent down-time period after accumulating operating times of 2500-3000 hours. The wear rates for vanes and rings for both cases are given in Table 2. It is again evident that the revised composition has shown better anti-wear characteristics. Thus, ring wear was reduced by 75 per cent and vane wear by 15 per cent. A marked difference in the wear pattern of the rings was observed. That from the pump operated on the former composition was stepped and scuffed as shown by the photograph (Figure 11). The ring lubricated by the

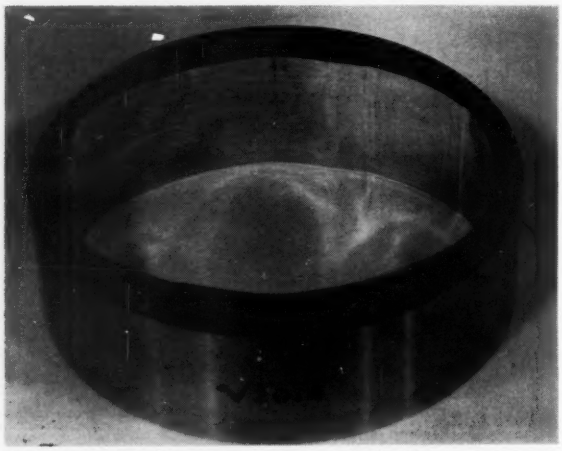


Figure 11. Ring from 10 gal/min constant-volume vane pump after operating on original emulsion for 2750 hours

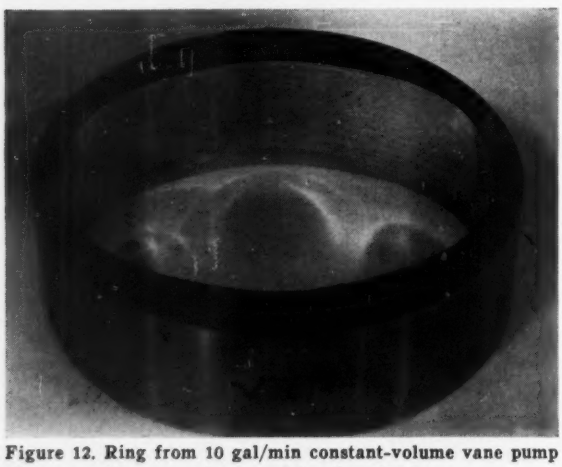


Figure 12. Ring from 10 gal/min constant-volume vane pump after operating on revised emulsion for 2890 hours

TABLE 3 WEAR PERFORMANCE* OF EMULSIONS IN COMMERCIAL SCALE DIE CASTING OPERATIONS

EMULSION	COMBINED OPER TIME, HR	WEAR RATE, GM/1000 HR	
		VANES	RING
1. Original Version	7600	3.59	3.41
2. Revised Version	8000	2.15	0.60
Improvement (2 OVER 1), %		40	82

*Data combined from various constant-volume 10 gpm vane pumps

revised composition (Figure 12) showed a major improvement.

The above examples were presented due to their similar operating periods. However, wear was determined quantitatively in several other identical pumps in the same die casting shop. The results have been combined to give the values shown in Table 3. These overall data present an even better performance rating for the current composition than is given by the individual examples.

Much of the improved performance shown by the revised formulation is undoubtedly due to its lower viscosity at low shear rates. This has been reflected particularly in quiet start-up of the pumps on die casting machines during cold weather. Under similar conditions, performance with the former composition was markedly noisier.

In summarizing the data on wear, all the information, both quantitative and qualitative, shows that the revision made in the emulsion-type hydraulic fluid has definitely improved its performance.

FIRE RESISTANCE

The reformulated product possesses the high degree of fire resistance shown by the original composition (3). Since then, additional instances (5) have occurred in commercial operations which have adequately demonstrated the effectiveness of the emulsion in this respect.

OTHER CHARACTERISTICS

Both laboratory tests and field observations have shown that the current composition is not corrosive to pump components or to metals commonly encountered in hydraulic systems. It is generally compatible with the customary seals and packing materials. Leather, of course, is subject to swelling because of the presence of water. Odor and toxicity are comparable to the corresponding properties of mineral oil.

SUMMARY

It has been shown that through a revision in the composition of the emulsion type hydraulic fluid, marked improvements in emulsion stability and anti-wear properties have been attained. This has been

(*Cont. on p. 404*)

Techniques for Surface Examination and their Contribution to our Knowledge of Friction and Wear

*by F. T. Barwell**

The response of a surface to a wearing process may be characterized by

(a) changes in topography

(b) changes in chemical nature

(c) changes in the physical structure.

The various methods available for study of these effects are reviewed, and the attempt is made to show them in perspective.

A survey is made of the factors entering into the wear process together with an analysis of the common machine elements from this point of view.

The approach is illustrated by reference to Mechanical Engineering Research Laboratory M.E.R.L. work on scuffing, and the power and limitations of the electron microscope as a research method are discussed.

INTRODUCTION

A real understanding of the basic mechanisms of the wear processes can be obtained only by a detailed study of the physical and chemical changes that occur on rubbing surfaces. Today the research worker has at his disposal a number of techniques, each one of which is particularly suitable for studying certain limited characteristics. His major problem is to synthesize the diverse information gained from application of these various techniques to form a coherent picture of how surface material is actually disarranged, displaced or dislodged, that is—worn. It is unfortunately true that, up to the present, it has not been possible to formulate any completely general account of the successive events in the wear process, but nevertheless the use of modern techniques has thrown much light on wear occurring in specific circumstances. Whether or not the various forms of wear occurring in industry will be found to be governed by common laws or whether each manifestation must be accounted for separately remains to be seen. Further progress depends in part upon a deeper understanding of both the potentialities and the limitations of the various techniques, so that the most appropriate tool may be selected for each particular phase of research. It is the purpose of this article to discuss the comparative merits of various methods of surface and subsurface examination and to illustrate their range of applicability by reference to research projects in current progress in the Lubrication Division of the Mechanical Engineering Research Laboratory.

* Electric Traction Engineer (Research), British Transport Commission, 14 Melbury Terrace, Marylebone, London, N.W.1, England, formerly Head of Lubrication and Wear Division, Mechanical Engineering Research Laboratory, Thorntonhall, Glasgow, Scotland.

CLASSIFICATION OF SURFACE CHANGES

Before discussing the techniques available for studying surfaces it will be convenient to classify broadly the various types of information that a research worker might wish to obtain when studying the basic processes of wear. Leaving aside for the present the grosser geometrical effects a researcher might expect to look for, these broad classifications are:

(a) changes in surface topography,

(b) changes in the chemical nature of the surface,

(c) changes in the physical structure of the surface.

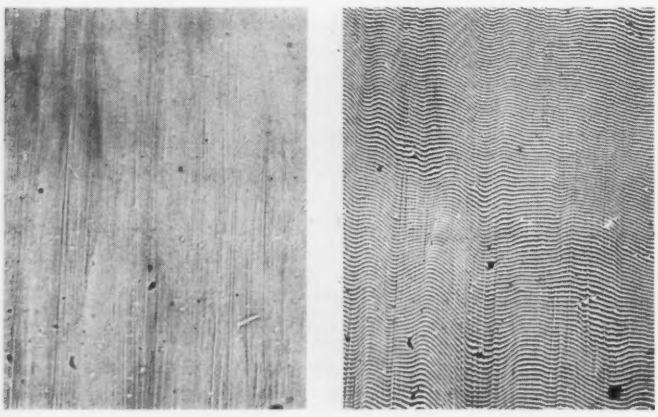
In general, the nature of wear is a complex mixture of several processes occurring either simultaneously or in sequence, and the scale of the phenomena may range from removal of large particles to the minute dimensions of the dislocations and vacancies in crystals. If a comprehensive picture of wear could be provided, it would enable this diversity of mechanism to be placed in its correct perspective, but for the present each worker must perforce be content to study a restricted range of phenomena, bearing in mind continuously, however, the probable relation of the phenomena being studied to others outside the scope of his particular investigation.

CHANGES IN SURFACE TOPOGRAPHY

In this type of phenomenon the research worker is interested in studying both the minute changes in the contours of surface asperities on a sub-crystalline scale and in the larger scale changes that may occur in the profile of the mechanism considered. Selection of the right tool therefore depends upon the object of

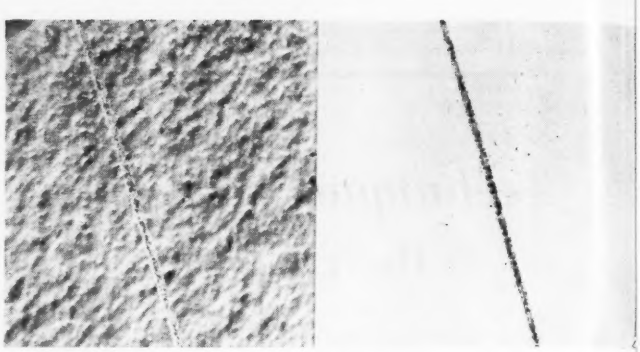
investigation. It is as important not to make too detailed an examination, with its restricted coverage, as it is not to make an insufficiently detailed study. Thus, in many instances concerning the performance of bearings and gears the localized effects of surface roughness may be overshadowed in importance by such factors as the degree of circularity of the journal or by the accuracy of tooth profile or by cumulative pitch errors. The work of the Metrology and Mechanisms Division of the Mechanical Engineering Research Laboratory (1) has been of great importance in the development and application of appropriate equipment for measurement of these relatively large-scale phenomena.

For the examination of surfaces on a more local scale, the value of stylus profilometers of various designs and of surface replicas is now well established and requires no emphasis here. There is a growing realization, however, that the rubbing characteristics of a surface depend not only upon the average on r.m.s. surface roughness of the irregularities, but also upon their quality or texture. There is a real need at present for a more adequate quantitative description of both the amplitude and wavelength distributions of real surface undulations. If this could be achieved, the way then would lie open for current speculations regarding the influence of surface asperities (2) to be tested against real rather than model surfaces. Any such development would need to take due account of the three-dimensional nature of surfaces, a point not always adequately brought out in representations of surface obtained by surface profile or sectioning techniques. The use of various optical techniques for studying surface topography with enhanced three dimensional effects has recently been surveyed by Scott (10). Of particular interest are the benefits that are obtainable by the use of interferometric methods (cf. Figures 1a and 1b) and by the use of phase-contrast illumination (cf. Figure 2a and 2b) in comparison with conventional normal illumination. Both these methods give a three-dimensional affect by image contrast. An



a. Normal. b. Interference.

Figure 1. Comparison of conventional and interferometric micrographs.



a. Phase contrast. b. Normal.

Figure 2. Comparison of phase contrast and normal illumination.

alternative method, much used in visual examination of surfaces but hampered by difficulties in adequate representation, is the stereoscopic viewing of surfaces. When used on negative replicas of surfaces care must be taken to allow for the inverted perspective.

If a more detailed examination of surfaces is required, the electron miscroscope may be employed to attain magnifications higher than those available with the optical microscope. Such examination may be made either by reflexion techniques directly from the surface or by transmission techniques from surface replicas. The former method (3) (Figure 3) appears to be more suitable for examining worn surfaces where the scale of damage is fairly large, but it requires the use of specimens sufficiently small to be inserted in the microscope or else expendable for cutting down to the size required. The latter method (Figure 4a) has the advantage that replicas may be taken from worn surfaces *in situ*, thus enabling the progress of wear

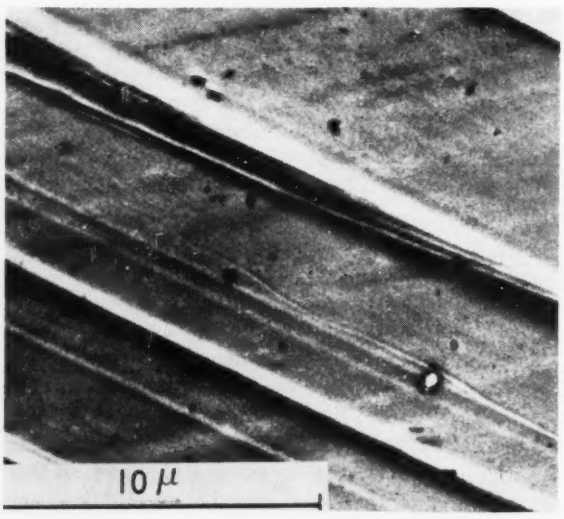


Figure 3. Reflection electron micrograph of diamond turned copper surface (after Halliday). (Angle of incidence 1° angle of observation 4°).

to be studied, but this method suffers from the usual disadvantages inherent in the use of replicas. These include the difficulty of stripping from rougher surfaces, particularly where re-entrant angles are present, and the difficulty of interpretation unless the precise direction of shadowing is known. Figure 4a illustrates the interesting optical illusions that are often present when micrographs are being studied—the markings may appear to the eye either to represent a shallow flake gouged out of the replica or smeared on. It is only the fortuitous presence of small pieces of formvar that have been distorted—perhaps by becoming entrapped in re-entrant spaces—that enables the direction of shadowing to be determined—hence the identification of the damage as pits in the replica and hence elevations on the initial surface. When the damage is more severe, the distortion of the replica may be sufficient to obscure the true nature of the surface (Figure 4b). Interpreted with care, however, the use of replica techniques may be of considerable assistance in the study of wear and of bringing out the importance of the early stages of the wear process (Milne, Scott and Macdonald, 1957; Grunberg and Campbell, 1957) (11), before the initial damage has been obliterated in subsequent rubbing.

THE PHYSICAL STRUCTURE OF SURFACES

The techniques referred to in the previous section have been appropriate primarily for the study of the surface topography. Of equal or greater importance than the topography is the physical state of the rubbing surface and its various adherent layers. The type of information required is, for example, a knowledge of whether the surface layers are amorphous or crystalline; if crystalline, whether there are preferred orientations and whether these are affected by rubbing; whether oxide films are dense or porous; whether defects in the crystal structure influence the rubbing process; and the mechanical properties of the various phases present.

For the study of crystal structure the value of X-ray diffraction and electron diffraction techniques have been now well established and used in particular to establish the orientation of various solid lubricants (4). More recently, Wilman has used X-ray diffraction to study the straining and rotation of surface material, an investigation of especial interest in the light of recent considerations of the plastic behaviour of surfaces in contact. The most serious disadvantage of these techniques is that they have very poor resolution and so yield information only of the behaviour of relatively large areas of the surface on a scale probably much larger than the primary contact areas. They rely also to a large extent on the presence of identifiable crystallographic structures.

The study of crystal defects has been considerably advanced by the work of Grunberg and Wright in these laboratories (5) and has been used in the examination of the complex mixture of metal and oxide material that comprises any real rubbing surface. These workers have studied the emission of electrons from surfaces suitably excited with light of various wavelengths and related this emission to the presence of oxygen-ion vacancies in the metal-rich oxide phases formed in the course of deformation. This work provides a novel and useful tool for studying a surface characteristic not readily examinable by other means.

A clear indication of the severe working which may occur in a solid as a result of frictional processes is provided by Figure 5 which shows a photomicrograph of a friction track made on rock salt by the passage of a steel sphere of ½ cm. radius under a load of 5 kg. In association with these tests, surfaces were exposed for short periods to action of X-rays and then placed adjacent to photographic plates. A clear image was produced on the surface which may be attributed to the fact that the energy of activation of X-ray can produce atomic displacements in the alkali halides near dislocations or other crystal imperfections. After 80 microns have been etched away, the extent of photographic blackening was only 2/5ths of that obtained when the original surface was treated. When 168 mi-

a. Initiation of damage with straight oil.

b. Damage occurring in presence of E-P lubricant.

Figure 4. Electron micrograph of damage on hard steel test piece.

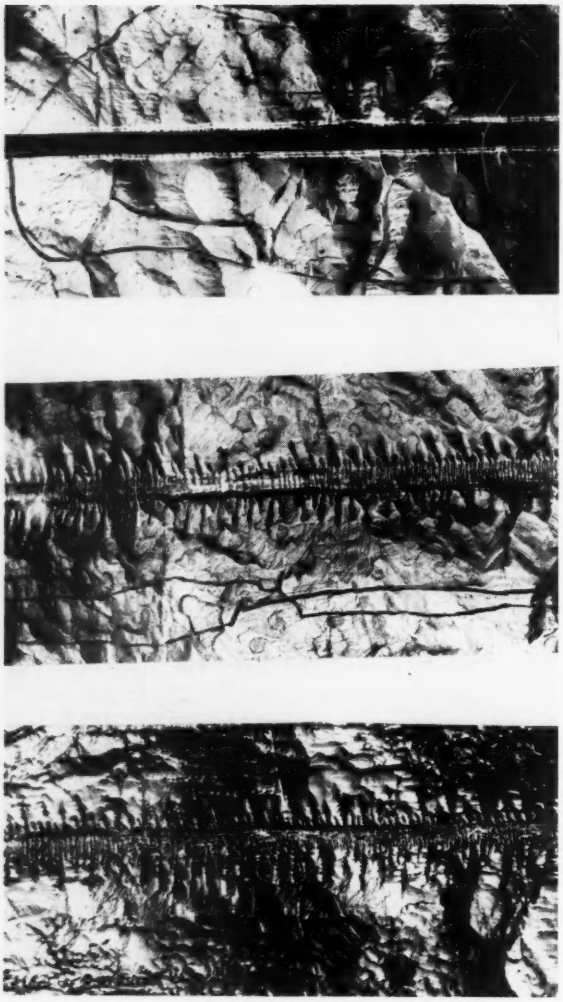


Figure 5. Photomicrographs of friction track at difference levels of rock salt crystal. Top (a.) shows original surface. Middle (b.) occurs after 80 microns have been etched away. Bottom (c.) occurs after 161 microns have been etched away.

crons were etched away, the blackening of the Q plate was negligible. It will be seen from the figure that there is still a considerable mechanical damage at the lowest level. It is believed that the action of plastic flow is to produce crystal imperfections which respond to X-rays in the manner described. The conclusion therefore is that in this particular material, the frictional process causes plastic working near the surface but that the deformation occurring deeply within the body is due to brittle rupture.

Although less spectacular, the value of the more conventional metallurgical techniques such as microhardness and etching, should not be despised, for they produce useful complementary information to that produced by the more advanced methods, while their resolution is, at the moment, superior.

CHEMICAL CHANGES OF SURFACES

The amount of material actually removed by direct chemical action from a surface is slight, and the most important effect of chemical changes upon a surface is probably in their effect upon the physical and mechanical properties. Micro-chemical methods of analysis do not yet appear to have reached a sufficiently high level of sensitivity to be of much value in studying surface properties in friction and wear studies. The most valuable tool at present available for the study of the removal and transfer of small quantities of material is probably that employing radio-active tracers. This method suffers from the disadvantage of a rather poor resolution, but amply compensates by its high sensitivity.

The use of radio-active tracer techniques has recently been applied by Grunberg and Campbell (6) in these laboratories to a study of the transfer of metallic particles in sliding friction experiments. These workers have shown that the amount of metal transfer and friction depend greatly upon the surface roughness and the method of surface preparation. They were able to estimate the relative components of metallic and lubricant friction and to show that the metallic component was high and velocity dependent on inferior boundary lubricant but to be very small when a good boundary lubricant was employed.

That protective surface films are produced by chemical reaction between lubricant and surface is now firmly established. A major uncertainty, however, lies in a knowledge of the precise nature of these films and, in particular, how they manage to prevent further disruption of the surface.

FACTORS AFFECTING WEAR

The wide range of combinations met with in industrial machinery, ranging from the intense transient loading of the gear tooth faces to the gentler but continuous loading of a whitemetal lining of a bearing, leads to such a vast number of combinations that a purely rational basis seems to be beyond the bounds of possibility. However an attempt may be made at classifying the best combination of load and speed and so forth, in order to achieve economy of effort. Figure 6 shows in an idealized manner the nature of contact

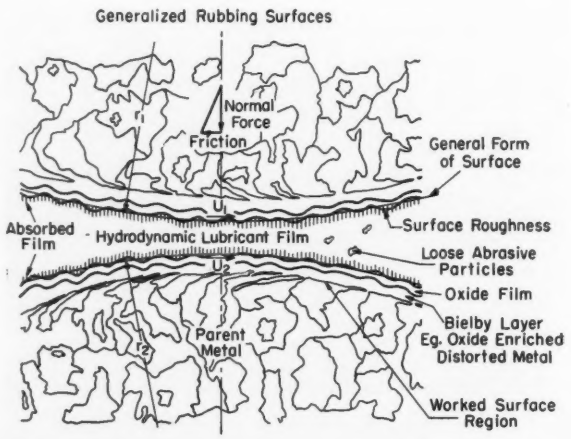


Figure 6. Idealized diagram of wearing surface.

between two rubbing surfaces. The factors governing any given situation may be classified broadly into three—the factors governing the form of the mating surfaces, the factors governing their duty (loads and speeds) and the factors governing environment, temperature, the presence or absence of corrosive and/or abrasive conditions.

Referring to Figure 6, the form factors are represented by the radii R_1 and R_2 and by two corresponding radii in the plane normal to them. A second most important factor is the load applied to the surface. This may be a constant force both in magnitude and direction, or it may vary both in magnitude and also in direction relative to the system as a whole. Therefore variations in space of the direction of load may be taken into account by selecting appropriate values of U_1 and U_2, it being understood that these velocities are measured relative to the line of action of the load. Where the surfaces are nominally flat, it is clear that contact will occur only at certain places as governed by the micro configurations of the surface, generally referred to as surface roughness. In the general case of curved surfaces, it is possible to estimate the stresses by means of Hertzian elastic theory. However the effect of irregularities which are almost certainly random in character will result in numerous concentrated contacts some of higher intensity than others. Thus plastic flow will take place and the plastic properties of bearing material or of the superficial layer assume importance.

Where hydrodynamic lubrication cannot be achieved, it is possible to obtain reasonably effective lubrication by employing boundary lubricants. These may function by physical adsorption onto the surface or more often they operate by reacting chemically therewith to provide material whose rheological properties enable load to be transferred between the surfaces without excessive interaction and damage. Vital, in any study of wear, is the true nature of the surfaces which in all practical cases involves some form of oxide film. The thickness of oxide films may vary considerably along the surface and the chemical composition is by no means uniform from inside to outside.

Immediately below the oxide film, and often mingled with it in an intimate way, is the true surface layer of the material. Depending on the method of manufacture, this layer may depart very considerably from the basic structure of the parent metal. Indeed the concept of an amorphous region was well established by Beilby. Most finishing processes will lead to a highly distorted metal which will often be enriched by oxide incorporated from the oxide layer. Then again, depending upon the method of manufacture and on the intensity of loading relative to the material properties of the parent metal, there may well be a layer of strained and distorted structure before the parent metal itself is reached. Considering the wide range of hardness, toughness, chemical reactivity of the materials available to modern technology, the selection for any application must leave a wide field for discrimination.

It will be seen that with all these factors entering into any practical application, a generalized treatment of wear—a treatment which would consider the effect of varying any factor against a background of the full range of possible variation of the other factors—would

TABLE 1. Analysis of Common Machine Elements

	FORM FACTORS					DUTY FACTORS					ENVIRONMENTAL FACTORS		
	CLOSE-CONFORMING	NON-CONFORMING	AREA	LINE	POINT	NATURE OF MOTION	SPEED, FPS U_1	SPEED, FPS U_2	NATURE OF LOAD	LOAD PSI	TEMP. °C	CORROSIVE	ABRASIVE
1. Plain journal bearing (turbine applications).	X			X		Continuous	300	0	Steady	300	Under 200	E. P. additives may be present	No
2. I.C. engine main and big end.	X			X		Continuous	50	Small reversing in big end	Reversing angular velocity	5,000	Under 200	Combustion and lub. breakdown products	Yes
3. Gudgeon Pin	X			X		Oscillating	Low	0	Reversing or variable uni-directional	10,000	Under 200	Combustion and lub. breakdown products	Yes
4. Plain thrust bearing.	X		X			Continuous	480	0	Steady	1,000	Under 200	E.P. additives	No
5. Spur and helical gears.		X		X		Slide/sweep ratio variable	200	200	Intermittent	Hertzian	Under 200	E.P. additives	No
6. Hypoid gears		X		X		Slide/sweep ratio variable			Steady with shocks	Hertzian	Under 200	E.P. additives	No
7. Ball Bearings		X			X	Steady	40,000 rpm	0	Steady	Hertzian	High	Lub. breakdown products	No
8. Roller Bearings		X		X		Steady	40,000 rpm	0	Steady	Hertzian	High	Lub.* breakdown products*	No
9. Pistons	X		X			Reciprocating	30	0	Intermittent	Low	High	Combustion and lub. breakdown products	Yes
10. Crosshead Guides	X		X			Reciprocating	20	0	Intermittent	Low	Under 200	No	No
11. Wheel and Rail				X		Steady	100	100	Impulsive	Hertzian	Low	Yes	Yes

The above factors represent the conditions which the designer has to meet. He has at his disposal two sets of variables, dimensions and materials.
* Special environments such as liquid sodium becoming important.

be quite impossible. Those who have responsibility for programmes of research on wear intended to be applicable to all industry cannot take a purely logical approach and work through all the effects of their combinations, but they must gamble to some extent on the selection of the most profitable regions of study. In Table 1 an attempt has been made to classify the number of machine elements in accordance with various criteria.

APPLICATION OF SURFACE EXAMINATION TECHNIQUES TO THE STUDY OF SCUFFING

As an example, let us consider the application of some of the above techniques to the study of a set of surface conditions embraced by items 5 and 6 of Table 1. Under these circumstances a particularly drastic form of surface failure occurs—scuffing or scoring of gears. From the gross geometrical view there is considerable evidence to show that accuracy of gear tooth profile and the amount of tip relief that is provided are of major importance. Tip relief is required with spur gears to compensate for the bending effect of the tooth loading, thus helping to insure smooth engagement of successive teeth, while accuracy of tooth profile also contributes to minimizing variations in load and hence excessive surface pressures. With helical gears, the lateral deflection of the tooth and the overall bending of the pinion can also cause apreciable deterioration in performance and allowance for these effects must be made in the gear design. Accurate measurement of the geometry of the teeth is essential to enable the correct modifications to be made, and considerable allowances have been made in recent years. A machine developed in the Mechanisms and Metrology Division of the M.E.R.L. for the study of the cumulative pitch errors in gears sufficiently small to be studied in the laboratory together with a portable instrument more suited for use on large marine gears are described in Reference 1.

Examining the gears on a closer scale, it is known that the method of manufacture can have an important influence upon the performance. Thus, gears that have been ground, shaved or hobbed can differ appreciably in performance. This may be due partly to differences in profile accuracy, but may be attributable in part also to differences in the local surface finish or to load differences in the metallurgical structure of the surface produced. It is known further that striking improvements in hypoid gear performance can be achieved by subjecting the gears to a chemical pretreatment, either phosphating or sulphiding. Here again the benefits obtained appear to be attributable to at least two complementary effects—improvement in meshing thereby reducing the severity of loading and improvement in the inherent resistance of the surfaces to failure caused by rubbing. Recent work carried out by Midgley under the auspices of M.E.R.L. has thrown further light on the manner in which phosphating affords protection to the surfaces. The conclusion reached was that the actual phosphate crystals themselves played only a minor part in the protective action, the major influence being the multitudinous plateaux and channels produced by the process. This forms an excellent example of the manner in which chemical action on a surface influences lubrication by its effect upon the physical and geometrical state of the final surface.

Continuing our investigation into an even closer study of the surface changes in gears we may refer to the studies of the action of sulphur as an E-P additive recently carried out by Dr. Campbell in these laboratories (7). Using radioactive techniques he found strong evidence of the formation of tenacious reaction products on the steel surface and was able to examine the manner in which these films were produced under different rubbing conditions (Figure 7). Milne, Scott and Macdonald (8) also found evidence of film formation on electron micrographs, the appearance of the deposits (Figure 8) suggesting that under some conditions reaction products are formed during passage of the contacts whereas under other conditions they appeared to have continued to be formed after passage of the contact. Continuance of such complementary studies should greatly assist our knowledge of the all-important running-in of surfaces.

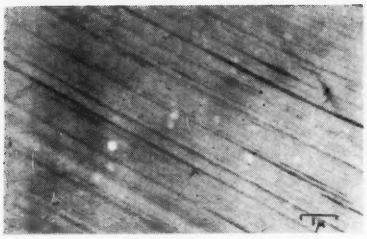
Delving still deeper into the specimen, the early stages of scuffing require the high resolution of the electron microscope to reveal the incipient damage, as shown recently by Milne, Scott and Macdonald (8).

a. Lubricant—Paraffin plus S-35.

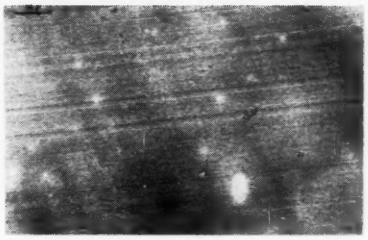
b. Lubricant—Paraffin plus S-35 + 5% Lead Naphthenate.

c. Lubricant—Paraffin plus S-35 + 10% Lead Naphthenate.

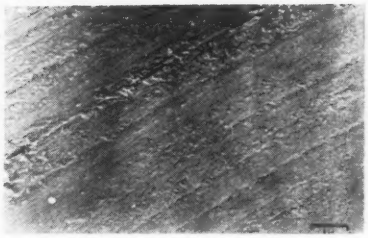
Figure 7. Autoradiographs of tracks on lower cylinder of crossed cylinder machine obtained using lubricant containing sulphur.



a. Original ground surface.



b. After one sweep with a mineral oil containing 1% of a chlorinated wax.



c. After one sweep across surface with a mineral oil lubricant containing 0.01% elemental sulphur.

Figure 8. Electron micrographs of surface of lower cylinder of crossed cylinder machine after operation in presence of E-P lubricants.

Figure 4a illustrates one type of initial failure where a shallow layer of material has been smeared on to the surface in a manner neatly explained by the recent studies by Greenwood and Tabor (9) on the plastic behaviour of model junctions. However, for studying the subsequent growth of the initial damage in subsequent or successive contacts the electron micrograph has too restricted a field and the development of failure is more readily observed at lower magnification from an optical microscope (Figure 9). When rippling of a gear tooth is under examination, even lower magnifications are required and a simple photograph (Figure 10) may suffice.

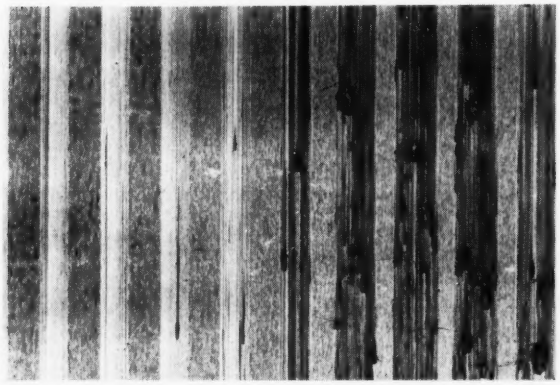


Figure 9. Optical micrograph of track on lower cylinder or crossed cylinder machine.

Figure 10. Photograph of rippling failure of hypoid pinion.

CONCLUSION

These examples have been put forward to illustrate the diversity of information that is required before a complete understanding of even one common rubbing process may be achieved. The more refined our modern techniques become, the more limited and restricted their scope becomes also. The researcher must make sure at all times that the particular phenomena he elects to study is viewed in its correct perspective with regard to the problem as a whole, otherwise he runs the risk of elaborating on trivialities and irrelevancies. Different workers will inevitably find their interest attracted by varying aspects of the particular subject and the need therefore remains for some workers at any rate to step back from the problem awhile and attempt to synthesize their diverse results into one coherent whole.

BIBLIOGRAPHY

1. Timms, C., The Measurement of Gears, *Engineering* Vol. 178, p. 789, London (1954).
2. Archard, J. F., *Proc. Roy. Soc. A.* Vol. 243, p. 190 (1957).
3. Mentor, J. W., *J. Inst. Met.*, Vol. 81, p. 163 (1952).
4. Finch, G. I., *Proc. Phys. Soc. A.* Vol. LXIII, p. 785 (1950).
5. Grunberg, L. and Wright, K. H. R., *Proc. Roy. Soc. A.* Vol. 232, p. 403 (1955).
6. Grunberg, L. and Campbell, R. B., I. Mech. E. Conference on Lubrication and Wear, (1957) Paper No. 65.
7. Campbell, R. B., I. Mech. E. Conference on Lubrication and Wear, (1957) Paper No. 61.
8. Milne, A. A., Scott, D., and Macdonald, D., I. Mech. E. Conference on Lubrication and Wear, (1957) Paper No. 97.
9. Greenwood, J. A. and Tabor, D., *Proc. Phys. Soc. B.* Vol. 68, p. 609 (1955).
10. Scott, D., I. Mech. E. Conference on Lubrication and Wear, (1957) Paper No. 57.
11. Scott, D. and Scott, H. M., I. Mech. E. Conf. Lub. & Wear, (1957) Paper No. 14. February, 1958.

ACKNOWLEDGEMENT

The work described has been carried out as part of the research programme of the Mechanical Engineering Research Board of the Department of Scientific and Industrial Research. The paper is published by permission of the Director of Mechanical Engineering Research.

ASLE Technical Digest

Papers which, because of space limitations, cannot be published in full in Lubrication Engineering or ASLE Transactions.

"Circulating Oil Systems—From 1/50 GPM to 50 GPM." E. W. Baumgardner, Trabon Engineering Corp.

Lubrication by continuous oil circulation has been accepted for years as one of the most dependable ways of assuring that enclosed mechanisms are protected adequately against wear and corrosion. The automotive engine testifies to this protection under a variety of operating conditions. Design is of course a basic requirement where considerable oil volume or flood lubrication prevail: the machinery must be enclosed in a leak-proof housing which must be designed for collection and return of the oil to the pumping element. Where the orifice type of system is involved, it functions on the basic principle that a given amount of oil of known viscosity will pass through any given aperture at a given pressure. Holding the pressure and oil viscosity constant, the degree of oil flow is controlled by varying the orifice.

In contrast in the more recently perfected piston displacement type of oil circulating system, the actual pump output is the governing factor as to the total volume of oil dispensed. This is relatively constant for any given pump and motor speed over a wide range of oil viscosities and operating conditions. Subsequent delivery via metering valves which incorporate the piston displacement principle results in accurate proportioning of the oil according to the preselected piston sizes within the series of valves which make up the system. Usually a master valve delivers oil to a set of secondary valves according to the number of outlets or the accuracy of oil control desired. This type of system enables normal operating pressures considerably higher than in the orifice type of system, i.e. 50 to 500 psi as compared to 15 to 70 psi.

The advantages attendant to the use of the piston displacement method of metering oil flow include: ability to handle a wide range of oil viscosities without change in system operation or inclusion of temperature control equipment, less chance of clogging or other disruption of oil flow, and the ability to handle successfully total oil volumes from as low as 1/50 gpm to about 50 gpm which is attainable in the conventional orifice type system. When it is desirable to apply oil circulation to machinery where exposed contact surfaces are to be lubricated, i.e. slides, ways or guides, precise control of oil delivery is decidedly important both from an oil collection and recirculation viewpoint, as well as in the interest of reducing oil throw, spillage or drip, which are wasteful and often hazardous. (*Digested by A. F. Brewer*)

"Car Oil Additives" L. C. Atchison, Denver & Rio Grande Railroad.

The waste packed sleeve type railway car wheel journal bearing is a unique device which can run economically with around 95% satisfaction even when poor oil, poor waste and mechanical defects are involved. That is not to say, however, that this is acceptable performance. The other 5% constitutes the headaches. In freight car handling, hot boxes are most troublesome on cars which are switched back and forth a number of times. The oil tends to drain off, sluggish wick action may develop also. Another cause of trouble is shifting of the bearing under the wedge due to rough track, wheels lifting and dropping on curves, humping of the car with certain loads such as liquids, high density sulfuric acid being particularly troublesome.

When the bearing shifts on the journal, it must necessarily reseat. Lubrication is vital. The availability of cars subject to the conditions contributing to trouble presented a setup which was ideal for field testing to develop data pertinent to the beneficial effect of fortifying additives in car oils. A variety of additives were studied, both as to type and percentage used. Zinc cetyl phosphate plus 4% of a solubilizer or sulfonate gave particularly good results, with more than one million miles of service per hot box. Continued study as to the right percentage of additive indicated 10% by volume as best. Volume below 10% gave no improvement over straight car oil. Above this amount, up to 25% did nothing that 10% would not do.

The effect of viscosity index was also studied since the AAR had, during the interval of test, changed the car oil figure from 80 to 100 VI., supposedly to correct waste grab in winter. The tests in question, using the successful additive containing zinc and sulfonate, indicated the lower viscosity index to be most satisfactory.

Obviously the use of an acceptable additive in a car oil implies a quality product. The increased cost is entirely justified when measured in terms of millions of miles of successful car wheel bearing performance. (*Digested by A. F. Brewer*)

"Starting Torque of Synchro Gear Train at High and Low Temperatures" C. K. Jeffries, Bell Telephone Laboratories, Whippany, New Jersey.

Synchro gear trains used in missile systems are required to operate over wide temperature ranges.

The paper is concerned with starting torque measurements for a particular gear train. Various tyes of lubricants were tested over a range of temperatures for −67°F to +350°F.

The lubricants tested and their usually specified temperature range were:

Mil-L-3545	−40°F to +300°F
Mil-G-3278	−65°F to +250°F
Mil-L-15719	−40°F to +350°F
Silicone Grease A	−40°F to +350°F
Silicone Grease B	−100°F to +450°F

Neither of the silicone greases are covered by government specifications.

Grease A contained a methyl phenyl silicone fluid and grease B a chlorinated silicone fluid.

In general it was found that the starting torque increased as the temperature decreased. Between +50°F and +250°F torque values were fairly constant.

Lubricant Mil-3545 was eliminated when a starting torque of 165 gram inches at −67°F was recorded for the gear unit tested. Mil-G-3278 and Mil-L-15719 had starting torques of 14 and 18 gram inches respectively at −67°F. The torque of the gear train when lubricated with silicone grease A rose from 3.0 gram inches at 75°F to 5.0 gram inches at −67°F. The starting torque of the gear train lubricated with silicone grease B changed only 0.5 gram inch throughout the entire temperature range and remained con-

stant at 2.5 gram inches from −25°F to +350°F.

Generally, the silicone greases are not recommended where the main action involves sliding metal on metal. However, faced with the problem of low starting torque at low temperatures under light bearing pressure, the author believes that the military will have no objection to the use of silicones.

It is not intended that a silicone grease be substituted in place of the present Mil-G-3278 general purpose grease, but that it be specified where the present lubricants are unsatisfactory and where other conditions permit its use. (*Digested by H. J. Connors*)

Note: Unabridged copies of the foregoing papers are not available at Society headquarters. Those wishing additional information about these papers should contact the author.

BOOK REVIEW

"Turning: Tools-Methods-Cuts" Walter G. Holmes.

An analysis program designed to increase production and reduce costs, this book presents data on machinability, tool types, tool angles, tool elements, tool materials, tool life, types of turning, tool on the centerline, chipbreakers, speed and feed for all types of screw machine tools, speed and feed for turning and boring, number of cuts, part finish, speed and feed for the different cutting tool materials, tool design for a particular cutting service, analysis of the time per piece, methods of estimating, machine replacement, cost analysis, the cost to manufacture the part, calculations of automation, feedback and the methods of tool and machine control.

Of interest to those interested in the use of the problems of speed and feed, the book details procedures of production and in economy. Cost analysis is used to determine cost, profit or loss.

The author shows how production costs are high when parts are produced on old, high-cost equipment. Explanation is made of how the rate and condition of production obtained from the machine, direct and indirect labor cost, maintenance and scrap should be checked against the use of modern equipment. The analysis methods in this book help determine the possibility of obtaining reduced costs and show the definite value of this reduction or savings.

SECTION NEWS

Chicago . . . Education course on problems dealing with practical lubrication is set for October 6, will continue every Monday through November 10. Cost of course is $10 to members, $25 to non-members. Location—Prudential Plaza, 130 E. Randolph Drive.

ASLE **ASME**

JOINT LUBRICATION CONFERENCE

October 13, 14 and 15, 1958

Hotel Statler, Los Angeles, Calif.

This conference is being planned and held under the joint sponsorship of the American Society of Lubrication Engineers and the American Society of Mechanical Engineers. Registration fee for members is $7.50, for non-members $12.50.

Monday—October 13

Session 1—RADIATION RESISTANT LUBRICANTS

—Development of Radiation Resistant Oils
—The Effects of High Energy Ionizing Radiation on Turbine Oil Performance Characteristics
—Visco-elastic Properties of Greases

Session 2—GAS AND LIQUID FILM BEARINGS

—The Influence of the Molecular Mean Free Path on the Performance of Hydrodynamic Gas Lubricated Bearing
—Axial, Relative Motion of a Circular Step Bearing
—The Gas Lubricated Sector Thrust Bearing
—Elastic and Damping Properties of Cylindrical Journal Bearings
—Analysis and Characteristics of the Three-Lobe Bearing
—The Effect of Offset Loading in Partial Journal Bearings

Tuesday—October 14

Session 3—AIRCRAFT AND MISSILE ACCESSORY LUBRICATION

—An Accessory Manufacturer's Approach to Bearing and Seal Development
—Development of Seals for Rocket Engine Turbopumps
—Mechanism of Gear Lubrication
—A Study of Design Criteria for Oscillating Plain Bearings

Session 4—BASIC STUDIES IN FRICTION AND WEAR—ADHESION AND SLIDING

—Adhesion Between Metals and its Effect on Fixed and Sliding Contacts
—An Investigation of Dry Adhesive Wear (I)
—Wear and Metal Transfer Between Sliding Surfaces (II)
—Transition Temperatures in Sliding Systems
—Metallic Friction and Wear at Elevated Temperatures

Wednesday—October 15

Session 5—BASIC STUDIES IN FRICTION AND WEAR—SPECIAL APPLICATIONS

—Film Formation by an Antiwear Additive in an Automotive Engine
—The Conduction of Current in Bearings
—A Surface Effect Associated with the Use of Zinc Dithiophosphate-Treated Engine Oils
—Wear and Friction of Filled Teflon Compositions in Liquid Nitrogen

Session 6—ROLLING CONTACT FATIGUE

—Operation of Ball Bearings Submerged in Liquified Gases
—Effect of Fiber Orientation, Temperature and by Powder Lubricants on Rolling Contact Fatigue
—Rolling Contact Fatigue of Bearing Materials and Lubricants Combinations
—Materials in Rolling Contact Bearings for Normal and Elevated 450 degree Temperatures

PRODUCT LITERATURE

HYDRAULIC TUBING BROCHURE

A 10-page illustrated brochure outlines the advantages of Republic Steel's electric resistance welded hydraulic line tubing and highlights how the high quality fatigue resisting pressure tubing flared and assembled. In addition to explaining points of manufacture, the new literature provides a complete list of specifications and features a table of recommended working pressures and size ranges. The brochure is available from Republic Steel Co., Steel and Tubes Div., 224 E. 131st St., Cleveland 8, Ohio.

FRICTION TESTER DATA

The new Hohman A-6 friction and wear tester is described and illustrated in a bulletin published by the Hohman Plating and Mfg. Co. The tester is a standard instrument used for the simulation of most types or combinations of wear, heat and atmospheric conditions that are encountered by solid lubricants. It can also be used for the wear or friction testing of many plastics and fibrous materials as well as oils and greases. For a copy of the bulletin, or further information on solid lubricants, write to Hohman Plating and Mfg. Co., 814 Vermont Ave., Dayton 4, Ohio.

WEIGHING SYSTEM CATALOG

Bulletin 581 covering Emery hydraulic tank weighing systems, has been published by the A. H. Emery Company, New Canaan, Conn. The catalog shows in detail the equipment available to team up with Emery load cells in providing indication, recording, printing and controlling in tank weighing installations. Replete with application drawing, the new bulletin describes in detail the operation of the load cells and the transducing elements used with the various cells. Of particular interest is the study of the exclusive Emery "rolling ball" head—a device which offsets the damaging results of cross loads which will occur with normal expansion and contraction of the tank. Copies of the new bulletin are available from The A. H. Emery Company, Pine Street, New Canaan, Conn.

FLOWMETERS DESCRIBED

The new line of Seico indicating flowmeters is described in two-color bulletin V-100 available from Seico Instrument Division, Eclipse Fuel Engineering Co., Rockford, Ill. Included in the bulletin are ranges, scales, pressures, and mechanical details of the complete line of flowmeters designed for use with air, gas and liquids. Besides this selection data, the bulletin contains an explanation of the exclusive movable vane principle of Seico flowmeters and the three systems of indication used in the various mediums being measured. Dimensional data and mounting arrangements for the various meter series are also included.

RECOMMENDATION SHEETS

A completely new series of lubrication recommendation sheets for Molub-Alloy, the metallic lubricant, has just been issued by the Imperial Oil and Grease Co., Inc. These sheets, available for most major industries, including transportation, give general lube recommendations for the use of Molub-Alloy, which will extend lube cycles up to 500 percent. Write for these sheets and other literature to Imperial Oil & Grease Co., Inc., 6505 Wilshire Blvd., Los Angeles 48, Calif.

BRUSH LINE BULLETIN

A complete line of carbon and graphite brushes for all types of rotating electrical machinery is described and illustrated in a new 12-page, two-color bulletin. Detailed information is given on selecting the right brush for a specific job, considering such factors as contact drop, coefficient of friction, loads, speeds, filming rates, brush hardness and strength. Separate sections are devoted to brushes for alternating and direct current equipment. Brush grade selection for specific types of machinery under these heading is tabulated by machine requirement. A separate table summarizes Speer brush grades by group, grade designation and key characteristics. For copies of Speer's new brush bulletin, "Brushes for Electrical Rotating Machinery," write to Speer Carbon Division, Speer Carbon Co., St. Marys, Pa., c/o Mr. Merle Lecker.

ENGINEERING AUDIT FOLDER

A four-page brochure discussing engineering audits as a proven technique for insuring against loss of market position through product obsolescence is now available from Designers for Industry, Cleveland, Ohio. Engineering audits described are aimed at a complete product line or an individual product. The publication also contains a synopsis of the integrated services available at Designers for Industry for product-process development. Copies of Engineering Audits may be obtained from Designers for Industry, 4241 Fulton Parkway, Cleveland 9, Ohio.

TESTER BULLETIN

A recently completed four-page bulletin on the new time saving Automatic Flash Point Tester, duplicating ASTM D56 results and needing no attendance during test, is now available from Precision Scientific Company, Chicago, Ill.

ASLE MEMBERSHIP CLASSIFICATIONS

Membership in the American Society of Lubrication Engineers is in several grades as defined below. Assignment to grade is made by the Admissions Committee or Board of Directors on the basis of information submitted by the applicant.

Members: Members shall be persons not less than 24 years of age who: (1) are engaged in research and instruction at technical schools, universities, and various publicly and privately supported institutions in the field of lubrication; or (2) have occupied recognized positions as lubrication engineers for a period of three or more (not necessarily consecutive) years prior to date of admission, involving the responsibility for or supervision of the development, selection, field use and application of lubricants as differentiated from other activities; or (3) are indirectly concerned with the field of lubrication, but possessing other qualifications of experience, knowledge, and accomplishment, and have manifested a particular interest in the purposes and welfare of the Society to the extent that their membership would be a valuable contribution to the successful functioning of its activities. Fee $15.00.

Associate Members: Associate Members shall be persons less than 24 years of age, and those who do not completely fulfill the membership requirements for Members. Fee $7.50.

Sectional Sustaining Members: are such persons or organizations as may be interested in and desire to contribute to the support of the purposes and activities of a local Section of the Society. Fee $25.00.

Industrial Members: Industrial Members are such persons or organizations as may be interested in and desire to contribute to supporting the purposes and activities of the Society. Fee $150.00.

For application blanks or further information, write:

ASLE
84 E. Randolph St.
Chicago 1, Ill.

Patent Abstracts

Compiled by Ann Burchick
Aluminum Co. of America

Lubricating Compositions, Patent #2,798,045 (F.A.M. Buck and G. T. Coker, Jr., assignors to Shell Development Co.) A lubricating composition comprising a major amount of a mineral lubricating oil containing about 2-5% of an oil-soluble basic calcium petroleum sulfonate, about 1-2% of a mixture of zinc dimethylcyclohexyl dithiophosphate and a P_2S_5-terpene-reaction product in the ratio of 5-1 respectively, and about 0.5-1% of N-C_{12-18} alkyl propylene diamine oleate.

Lubricant Containing Hydrogenated Liquid Polymer Oils, Patent #2,798,853 (D. W. Young and D. L. Cottle, asignors to Esso Research & Engineering Co.) A lubricating oil composition which comprises a mineral lubricating oil base stock containing a minor but extreme pressure resistance improving amount of the reaction product of a sulfide of phosphorus with a hydrogenated polymer prepared by hydrogenating the oily polymer obtained by copolymerizing 50 to 100 parts by weight of butadiene—1, 3 and 50 to 0 parts by weight of styrene in the presence of finely divided sodium, said hydrogenated polymer having an ASTM iodine number below 150.

Foam Inhibition of Oil, Patent #2,799,650 (J. P. McDermott and M. F. Hurley, assignors to Esso Research & Engineering Co.) An oil composition of reduced foaming tendencies comprising a major proportion of an organic oil composition of viscosity at least as high as kerosene and a minor detergency-improving proportion of about 5% by weight of a normally foam-promoting detergent additive selected from the group consisting of the alkaline earth metal salts of alkyl phenol sulfides, the phospho-sulfurized derivatives of said salts, and mixtures of said salts, which has been stirred and heated prior to incorporation in said oil, together with about 0.1-25% by weight, based on the additive, of mesityl oxide at a moderately elevated temperature in the neighborhood of about 160°C.

Corrosion Inhibitors and Compositions Containing the Same, Patent #2,799,651 (E. E. Richardson, C. S. Scanley and E. K. Fields, assignors to Standard Oil Co.) A lubricant composition comprising a major proportion of an oleaginous compound containing a substance normally corrosive to silver selected from the group consisting of elemental sulfur, a sulfur-containing organic compound and mixtures thereof, and from about 0.02% to about 10% of a thiadiazole having the general formula in which R is a hydrocarbon radical having from 2 to about 30 carbon atoms and x is an integer of from 1 to 9.

Corrosion Resistant Composition, Patent #2,799,652 (E. K. Fields, assignor to Standard Oil Co.) A lubricant composition comprising a major proportion of an oleaginous material containing a compound normally corrosive to silver selected from the group consisting of elemental sulfur, a sulfur-containing organic compound and mixtures thereof and from about 0.02% to about 10% of an oil-soluble reaction product of 2,5-dimercapto-1, 3, 4-thiadiazole, and an unsaturated ketone having at least one olefinic double bond, and from about 4 to about 40 carbon atoms selected from the class consisting of an unsaturated aliphatic ketone and an unsaturated aromatic ketone, said reaction product being obtained by reacting said thiadiazole and said ketone in the molar ratio of from 1:2 to 4:1, respectively, at a temperature of from about 40°C to about 140°C.

Method of Stabilizing Lubricant Additive Compositions, Patent #2,799,653 (C. S. Scanley, assignor to Standard Oil Co.) The method of preparing a stable compatible composition comprising in admixture a hydrocarbon lubricating oil, from about 20% to about 98% of an oil-soluble reaction product of a phosphorus sulfide and a hydrocarbon, neutralized with an alkali metal basic compounds, and from about 2% to about 80% of a polyvalent metal salt of a dihydrocarbon dithiophosphate normally unstable in said composition, comprising heating said admixture at a temperature of from about 240°F to about 450°F for at least one-half hour until a cooled sample of the heat-treated mixture remains clear without developing a precipitate after about at least three weeks.

Non-Corrosive Lubricant Composition, Patent #2,799,654 (A. R. Sabol and R. E. Karll, assignors to Standard Oil Co.) A lubricant composition comprising a major proportion of an oleaginous compound and from about 0.1% to about 10% of the neutralized reaction product of a sulfurized terpene, an alkyl phenol selected from the group consisting of a monoalkyl phenol and a dialkyl phenol having 2 to about 20 carbon atoms in each alkyl radical, and formaldehyde, said reactants being reacted in the molar ratio of from 1:0.1:0.1 to about 1:1:1, respectively, at a temperature of from about 150°F to about 300°F and the resultant product neutralized with a basic reagent.

Non-Corrosive Lubricant Composition, Patent #2,799,655 (A. R. Sabol and R. E. Karll, assignors to Standard Oil Co.) A lubricant composition comprising a major proportion of an oleaginous compound and from about 0.1% to about 10% of an oil-soluble salt of the reaction product of a chlorinated sulfurized terpene and an alkyl phenol selected from the group consisting of a monoalkyl phenol and a dialkyl phenol having 2 to about 20 carbon atoms in each alkyl radical, said reactants being reacted in the molar ratio of from 1:1 to about 1:4, respectively, at a temperature of from about 40°F to about 100°F.

Novel Complex Lubricating Grease Composition, Patent #2,799,656 (L. A. Mikeska and J. H. Bartlett and A. J. Morway, assignors to Esso Research & Engineering Co.) A lubricating grease composition which consists essentially of a lubricating oil base stock thickened to a grease consistency with a mixture of a complex of a metal soap of a high molecular weight fatty acid and a metal salt of a low molecular weight acid combined with a metal soap.

Lubricating Oil Additives, Patent #2,799,657 (E. L. Cole and W. E. Skelton, assignors to The Texas Co.) An additive for mineral lubricating oil consisting essentially of an oil soluble isobutylene-butadiene-hydrogen sulfide polymer containing 0.5-15 weight percent sulfur, having average molecular weight between about 2000 and about 7000, and prepared by polymerizing, in a reactor with Friedel-Crafts catalyst, from 2-20 mols of isobutylene with a mol of butadiene and about 0.05 to about 0.8 mol of hydrogen sulfide per olefinic double bond in said hydrocarbon reactants as fed to the reactor.

Lubricating Compositions, Patent #2,800,450 (A. A. Bondi and H. Diamond, assignors to Shell Development Co.) A lubricating composition comprising a major amount of a mineral lubricating oil from 0.01% to 10% by weight of an oil-soluble hydrolyzed copolymer of an alpha hydrocarbon-olefin having at least 8 carbon atoms with a vinyl ester of a lower fatty acid having from 1 to 5 car-

bon atoms respectively, in the mol ratio of from 1/1 to 1/5, respectively, said hydrolyzed copolymer product having a molecular weight of from about 1,500 to about 50,000, and from 0.01% to 5% of an oil-soluble organid dithiophosphate.

Stabilized Hydrocarbon Compositions, Patent #2,800,452 (A. A. Bondi and H. A. Newey, assignors to Shell Development Co.) A hydrocarbon oil composition containing a minor amount, sufficient to stabilize said oil against oxidation and sludging, of an oil-soluble polymeric reaction product formed by reacting a 1-olefin having at least 10 carbon atoms with an ester of an acrylic acid and a lower alkanol of from 1 to 3 carbon atoms in the mol ratio of from 1:5 to 5:1, respectively, in the presence of a peroxide type catalyst, and thereafter amidizing at least 10% of the said ester groups in the polymer with an amine containing a substituent polar group.

Liquid Hydrocarbon Compositions, Patent #2,800,453 (A. A. Bondi and L. B. Scott, assignors to Shell Development Co.) An improved hydrocarbon oil composition comprising a major amount of a hydrocarbon oil having incorporated therein a minor amount sufficient to impart stability and detergency to said hydrocarbon oil of a high molecular of from about 4,000 to 50,000 hydrolyzed copolymer of an α-hydrocarbon-olefin having at least 10 carbon atoms with a vinyl ester of a low fatty acid having from 1 to 5 carbon atoms, in the mol ratio of from 1/1 to 1/5, respectively.

Manufacture of Synthetic Lubricants in the Presence of Phenothiazine, Patent #2,800,500 (A. H. Matuszak, W. W. Gleason, D. W. Young and D. L. Cottle, assignors to Esso Research & Engineering Co.) In a process for the preparation of complex ester synthetic lubricants from branched chain alcohols, glycols, and dicarboxylic acid in the presence of an esterification catalyst, the improvement which comprises carrying out the esterification reaction in the presence of from about 0.05% to about 2.0% by weight of phenothiazine.

Esters of Mixed Dicarboxylic Acids, Patent #2,801,219 (J. P. Buckmann, assignor to Union Oil Co. of California) A lubricating grease suitable for use at sub-zero temperatures, said grease consisting of a lubricating oil containing between about 3% and about 35% by weight of a thickening agent selected from the class consisting of metal soaps, silica and alumina aerogels, alkyl ammonium bentonites and metal phthalocyanines, said lubricating oil comprising an ester having a pour point between 30 F. and -100 F., a kinematic viscosity between about 3 and about 35 centistokes at 100 F. and being obtained by esterifying an acid mixture having a saponification number-acid number ratio between about 1.2 and about 1.32 to 1 with a compound selected from the class consisting of the monoalkyl ethers of glycols and polyglycols, said acid mixture being obtained by air blowing a refined paraffin wax having a melting point between about 120 F. and about 165 F. at a temperature between about 210 F. and about 260 F. and a pressure between atmospheric pressure and 500 pounds per square inch until the acid number of the oxidized wax is at least about 490 mg. KOH/g., the rate of air blowing being initially between about 0.75 and about 1.25 standard cubic feet per minute per 100 pounds of wax and said rate being increased as the oxidation proceeds to between about 1.5 and 2.0 standard cubic feet per minute per 100 pounds of wax at 90 hours, said last named rate being maintained to the end of the period of oxidation.

Production of Lubricating Greases from Monohydric Alcohol Esters of Hydroxy Fatty Acids, Patent #2,801,220 (M. K. Smith, assignor to The Baker Castor Oil Co.) In the manufacture of lubricating greases, the method which comprises heating about stoichiometric proportions of a metal compound selected from the group consisting of hydroxides, oxides, and carbonates of alkali metals, alkaline earth metals, and aluminum together with an ester of an aliphatic monohydric alcohol having from 1 to 5 carbon atoms and a hydroxy fatty acid having from 9 to 24 carbon atoms in an unsaponifiable lubricant base to a soap-forming temperature, said metal compound and said ester being in sufficient amount so that the resulting soap imparts a grease consistency to the lubricant base, and then heating the mixture to a higher temperature sufficient to form a grease upon subsequent cooling.

Jet Turbine Lubricants, Patent #2,801,-968 (N. W. Furby, J. M. Stokely and E. G. Foehr, assignors to California Research Corp.) A lubricant composition made up of from about 90 to 98% by weight of a methyl sec.-butyl diether of poly-1, 2-oxypropylene glycol having a molecular weight between about 315 and 700, from 0.5 to 3% by weight of a dialkyl selenide wherein the alkyl groups each contain from 6 to 18 carbon atoms, from 0.1 to 0.5% by weight of a blend of dodecylamine dodecyl acid phosphate and dodecyl dihydrogen phosphate wherein the dodecylamine salt constitutes from 25 to 95% by weight, from 0.5 to 5% by weight of tricresyl phosphate, from 0.01 to 0.1% by weight of quinizarin and from 0.0001 to 0.2% by weight of dimethyl silicone.

Lubricating Greases Thickened with Soaps Obtained by Alkali Fusion of Amino Alcohols, Patent #2,801,969 (A. J. Morway and J. H. Bartlett, assignors to Esso Research & Engineering Co.) A lubrication grease comprising a lubricating oil and a grease making proportion of a grease thickener comprising an alkali metal soap of an organic acid produced by fusing an amino alcohol with alkali at a temperature in the range of 400 to 620 F. until gas evolution substantially ceases, said alcohol having about 10 to 50 carbon atoms per molecule.

Preparation of Lubricating Grease Compositions from Oxo Reaction Products, Patent #2,801,970 (J. H. Bartlett, A. J. Morway and J. C. Munday, assignors to Esso Research & Engineering Co.) A process for the preparation of new and useful lubricating grease compositions which comprises the steps of reacting an olefinic hydrocarbon with carbon monoxide and hydrogen in the presence of a carbonylation catalyst at a temperature of about 200 F. to 400 F. and at a pressure of about 200 to about 300 atmospheres to obtain a mixture of products, removing unreacted hydrocarbons from said mixture of products by a distillation step, treating said mixture of products with an excess of an alkali metal hydroxide at a temperature of about 500 F. to 650 F. for about 4 hours, quenching said mixture of products in about 5 to 10 volumes of water, extracting said quenched product with petroleum ether to recover a mixture of acetals, and thickening said mixture of acetals to a grease consistency with from about 5% to about 20% by weight of a mixture of lithium soaps of hydrogenated fish oil acids and the lithium salt of acetic acid.

Manufacture of Lubricating Greases by the In Situ Alkali Fusion of Alcohols, Patent #2,801,971 (J. H. Bartlett, A. J. Morway and L. A. Mikeska, and S. G. Gallo, assignors to Esso Research & Engineering Co.) The proces of preparing a lubricating grease which comprises mixing a mineral lubricating oil with alkali, sufficient in amount for fusion and saponification, heating the resulting mixture to a temperature in the range of 450 to 500 F., slowly adding to the heated mixture over a time in the range of 1 to 20 hours a stoichiometric proportion of an alcohol while maintaining a fusion-reaction temperature within the range of 475 to 560 F., continuing heating at the fusion-reaction temperature until gas evolution ceases, cooling the reaction mixture, and diluting the reaction mixture with additional lubricating oil to obtain the desired grease consistency, said alcohol consisting of a branched chain primary aliphatic alcohol having from about 10 to 30 carbon atoms per molecule, prepared by the catalytic reaction of an olefin having one carbon atom less than said alcohol with carbon monoxide and hydrogen at a temperature in the range of 300 to 400 F. and a pressure in the range of 2500 to 4000 p.s.i.g. in the presence of a group VIII metal catalyst, followed by catalytic hydrogenation of the aldehyde so formed.

Manufacture of Lubricating Greases by Alkali Fusion of Ether Alcohols, Patent #2,801,972 (J. H. Bartlett, A. J. Morway and L. A. Mikeska, assignors to Esso Research & Engineering Co.) A process of preparing lubricating grease compositions which comprises dispersing in ether alcohol, having a primary alcohol group and an ether group having

from about 10 to 50 carbon atoms per molecule, in a dispersing-proportion of a lubricating oil, heating said dispersion to a temperature within the range of about 130 to 180 F., adding sufficient sodium hydroxide to said heated dispersion for fusion and saponification, heating the resulting mixture to an alkali fusion-reaction temperature within the range of about 400 to 620 F. until hydrogen gas formation has receded, and then cooling the resulting grease mixture to obtain said lubricating grease composition.

Grease Process Utilizing the Alkali Fusion of Aldehydes, Patent #2,801,973 (A. J. Morway, J. H. Bartlett and L. A. Mikeska, assignors to Esso Research & Engineering Co.) The process of preparing lubricating grease compositions which comprises mixing an aliphatic aldehyde having an alpha hydrogen and from about 10 to 30 carbon atoms per molecule and a high molecular weight carboxylic acid having from about 12 to 22 carbon atoms per molecule with a dispersing proportion of mineral lubricating oil, heating the mixture to about 130 to 180 F., adding a low molecular weight carboxylic acid and alkali sufficient for neutralization of said acid and for alkali fusion of said aldehyde to said heated mixture, dehydrating the mixture at a temperature of about 300 to 400 F., heating the dehydrated mixture at a fusion temperature of about 400 to 620 F. sufficient to cause fusion between said alkali and said aldehyde until gas evolution recedes, and then cooling the grease mixture to obtain said lubricating grease composition.

Grease Process Utilizing the Alkali Fusion Products of Cyclic Alcohols, Patent #2,801,974 (A. J. Morway and J. H. Bartlett, assignors to Esso Research & Engineering Co.) A process for preparing a lubricating grease which comprises: admixing a mineral lubricating oil with 2-30 weight percent, based on final composition, of a fatty acid having from 12 through 22 carbon atoms, 1-10 weight percent, based on final composition, of a low molecular weight carboxylic acid, and a cyclic primary alcohol having 10 through 20 carbon atoms, the amount of said alcohol being sufficient for the salt derived therefrom by subsequent alkali fusion to amount to 2-20 weight percent of the final composition, and the mol ratio of the salt derived from said alcohol to the soap and salt derived from said fatty and carboxylic acids being in the range of 1:4 to 4:1; adding to the resulting admixture sufficient sodium hydroxide to neutralize all acids present and to convert by subsequent alkali fusion said alcohol into the corresponding acid salt; heating the admixture to a saponification temperature in the range of 300 to 400 F. until all acids originally added are converted to soaps and salts, and the water present is substantially removed by volatilization; then further heating the admixture to an alkali fusion temperature in the range of 500 to 580 F.; maintaining the admixture at said alkali fusion temperature until gas evolution recedes substantially; and cooling the thus heated admixture to obtain a lubricating grease composition.

Preparation of Grease Thickeners by Alkali Fusion of Polyvinyl Esters, Patent #2,801,975 (J. H. Bartlett and A. J. Morway, assignors to Esso Research & Engineering Co.) The process of preparing lubricating greases which comprises contacting a polyvinyl ester having a molecular weight of about 1,000-200,000 with an alkali metal hydroxide at conditions including a temperature in the range of 480 to 600 F. conducive to alkali fusion in the presence of a preformed alkali metal soap of a high molecular weight fatty acid at least until substantial amounts of hydrogen have been liberated, producing a metal soap material from the acidic material formed by fusion and incorporating said soap and material into a lubricating oil in grease making proportions, said soap amounting to 2-30 wt. percent and said material amounting to 2-20 wt. percent of the final grease composition.

Lubricating Greases Containing Alkali Fusion Products of Polysaccharides, Patent #2,801,976 (A. J. Morway and J. H. Bartlett, assignors to Esso Research & Engineering Co.) A lubricating grease comprising a major proportion of a mineral lubricating oil and grease-making proportions of a grease thickener containing a substantial proportion of an alkali metal salt of a low molecular weight aliphatic acid and at least about 20% by weight based on total thickener of an alkali metal salt of a high molecular weight carboxylic acid, said salts being produced by the saponification and alkali fusion at a temperature of about 400-600 F. of an ester of a polysaccharide having at least about 24 carbon atoms per molecule with said low molecular weight acid.

HELP WANTED

ASSISTANT RESEARCH DIRECTOR
RESEARCH SUPERVISOR

Physical chemist with substantial experience in lubricants or metalworking products. Should be 30-40, have mechanical aptitude, supervisory experience, administrative talent, Ph.D. preferred, be energetic and creative. Middle Atlantic States location. Unusual opportunity. Reply to Box LE-9.

mbi
ON GUARD SINCE 1888

LUBRICATING GREASES
METAL WORKING LUBRICANTS
SPECIAL PROCESS OILS

"Never Underestimate the Importance of Lubrication"

•

Consult Our Lubrication Engineers

MAGIE BROTHERS OIL COMPANY
FRANKLIN PARK, ILLINOIS
CHICAGO PHONE: TUXEDO 9-4800

Fire Resistant Hydraulic Fluids

(*Cont. from p. 390*)

and renovation for one railroad gives statistics with accomplished without detriment to other characteristics. These improvements present an advancement toward the goal of an emulsion type hydraulic fluid with all of the excellent characteristics of mineral oils but possessing a high degree of fire resistance.

ACKNOWLEDGMENT

The authors wish to express their appreciation of the cooperation of the several member shops of the American Die Casting Institute which have greatly assisted in the field testing of these and additional fluids.

BIBLIOGRAPHY

1. Millett, W. H., "Fire Resistant Hydraulic Fluids—Aqueous Base Types," *Applied Hydraulics,* June, 1957, p 124.
2. Langenfeld, F. H., "Fire Resistant Hydraulic Fluids—Phosphate Ester Base Types," *Applied Hydraulics,* August, 1957, p 114.
3. Coker, G. T., Jr. and Francis, C. E., "The Place for Emulsions as Fire-Resistant Power Transmission Fluids," *Lubrication Engineering,* September-October, 1956, p 323.
4. Homeon, J. Russell, "Magnetic Plug Assemblies," *Applied Hydraulics,* March, 1957, p 73.
5. Jackson, Lawrence, "Fire-Resistant Hydraulic Fluids for the Die Casting Industry," *Precision Metal Molding,* June, 1957.

Oil Reclamation

(*Continued from p. 384*)

regard to oil that is reclaimed or used in the reclaiming process. Because of the availability of economical oil reclamation, this railroad, over a 10 year period, found it possible to renovate 69,400,000 lb of journal box packing, with a replacement value of $8,328,000, for only $1,388,000, a savings to the railroad of $6,940,000 or a savings of 84% of the total value of material reclaimed.

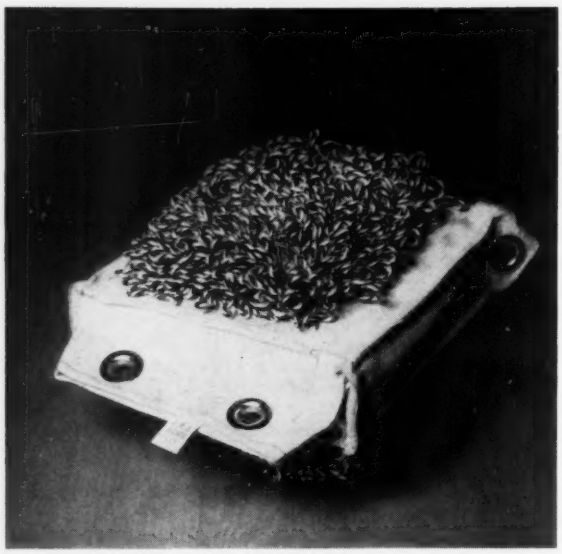


Figure 5. A manufactured lubricator.

ADVERTISERS INDEX

Acheson Colloids Co. 376
Baroid Div., National Lead Co. 365
Brooks Oil Co. 363
Cities Service Oil Co. 380
Dametallic Corp. 377
Farval Corp., The .....Second cover
Hodson Corp., The .....Fourth cover
King, O. L. Co. 378
Lincoln Engineering Co. 373
Magie Bros. Oil Co. 403
Norgren, C. A. Co. 371
Oronite Chemical Co. 367
Trabon Engineering Corp. .....Third cover
Help Wanted 403

In addition to the journal box packing, 285,000 lb of bearing material was recovered and returned to the railroad for their disposition. This saving is possible only because of the economical method of reclaiming oil.

FUTURE OF RECLAMATION

The recent crises in the Middle East beginning with that caused by the closing of the Suez Canal and the cutting off of the vital oil supply that is located there, focused our attention on the limited amount of lubricating oil that comprises the world's known reserves. With the increased mechanization of industry and automation, lubricating oils are becoming more in demand, and naturally with demand comes the ever-increasing rise in cost. Today, the railroads pay an average of 37 cents per gallon for new journal box lubricating oil. This is 11 times as much as the 3.3 cents per gallon necessary to reclaim a gallon of oil meeting the same specifications and capable of doing the same job. Lubrication of journals is only one part of the lubrication picture in the railroad industry and it is quite apparent that they consider the reclamation of the oil used in the journal boxes to be a major way to save and reduce operating cost. The reclamation of journal lubricating oil becomes more important as better quality new oils are specified.

TRABON

CENTRALIZED LUBRICATING SYSTEMS

Make more profit per stamping with Trabon

Stop a press due to lack of lubrication and your cost per stamping soars! Add up the man hours it takes to lubricate a press by hand and it will stagger you. Yet, each time your press is down because of these reasons, you are losing money.

That's why manufacturers and operators install Trabon on their presses. A Trabon Centralized Lubricating System delivers the **exact** amount of oil or grease to bearings wherever located. Trabon does this automatically or manually, for hydraulic, mechanical, electric motorized and pneumatic equipment. In this way, Trabon protects expensive bearings, eliminates downtime due to haphazard lubrication, saves lubricant. Be sure to install Trabon on your equipment — soon! You'll reap the benefits immediately!

"Whitened" Trabon pumps and feeder valves provide these Verson eccentric presses with the exact amount of lubricant needed. Note the centralized warning-light system facing the operator, a standard Trabon feature.

Trabon

Trabon Engineering Corporation

28787 Aurora Road • Solon, Ohio

Centralized OIL AND GREASE SYSTEMS *Motorlift* CIRCULATING OIL SYSTEMS

Lubrichanics by Hodson

SOAKING PIT COVER LUBRICATION

#0-2000 NOMELT LUBRICANT for bearings of cover carriage line shafting, wheel bearings, lifting locks, eccentrics, etc.

HODSON NOMELT is a development of Hodson engineering research. Compounded with mineral oils of various types and specifications, blended with inhibiting agents to prevent corrosion and oxidation, and fortified with a non-soaping gelling ingredient, resulting in a unique lubricant.

HODSON NOMELT LUBRICANT does not melt at high ambient temperatures of above-normal operations. Burning tests on hot plates and in crucibles left only minimum residue of carbon. Appearance of the residue is like carbon black, not coked clinkers or gummy rosins and, in this form under certain operating conditions, it would retain some lubricating value.

HODSON NOMELT LUBRICANT is now successfully used in sintering plants, open hearth and blast furnace operations, rolling mills, for dogs and dollies of hot beds, furnace table roller bearings, pinch roller bearings, soaking pit crane columns, coilers, transfer tables, pallet wheels, kiln car journals, coke oven door latching devices, reversing mechanism, coke batteries, larry cars, charging cars, pushers, wedges, cartridge boxes, tube mills, Schloemann rolls, furnace screws and electrolytic tinning line roll bearings.

#1259 H.F. (High-Flash) GEAR OIL for cover lift and transverse drives —for both bearings and gears.

#1259 H.F. GEAR OIL is a compounded high fire and flash filtered stock recommended for drive installations operating adjacent to furnaces, hot beds, sintering plants, etc. where above normal operating temperatures are experienced.

Due to its excellent viscosity index, the #1259 H.F. GEAR OIL may be used at prolonged intervals without replacement as it will not oxidize or disintegrate under above normal conditions. It has excellent E. P. (extreme pressure) qualifications, carrying 65# lever load on the testing machine.

Detailed specifications furnished upon request.

The HODSON CORPORATION

A I S E Exposition
Booth No. 342
Cleveland Public Auditorium
Cleveland, Ohio
September 23, 24, 25, 26, 1958

Lubrication

NOMELT is a registered trade mark of The Hodson Corporation

5301-11 West Sixty-Sixth Street
CHICAGO 38, ILLINOIS

9-L-58

Printed in U.S.A.